1661-8726/09/020271-25
DOI 10.1007/s00015-009-1317-1
Birkhäuser Verlag, Basel, 2009

Swiss J. Geosci. 102 (2009) 271–295

Formal proposal for the Bathonian GSSP (Middle Jurassic) in the Ravin du Bès Section (Bas-Auran, SE France)

Sixto R. Fernández-López [1,*], Giulio Pavia [2], Elisabetta Erba [3], Myett Guiomar [4], Maria H. Henriques [5], Roberto Lanza [2], Charles Mangold [6], Davide Olivero [6] & Daniele Tiraboschi [3]

Key words: Bathonian GSSP, chronostratigraphy, biostratigraphy, geochronology, Ammonoidea, calcareous nannofossils

ABSTRACT

The Bathonian Global Stratotype Section and Point (GSSP) is proposed at the base of limestone bed RB071 (bed 23 in Sturani 1967) in the Ravin du Bès Section (43º 57' 38" N, 6º 18' 55" E), Bas-Auran area, "Alpes de Haute Provence" French department. The Ravin du Bès Section, as formal candidate GSSP for the base of the Bathonian Stage, satisfies most of the requirements recommended by the International Commission on Stratigraphy: 1) The exposure extends over 13 m in thickness. At the Bajocian-Bathonian transition, no vertical (bio-, ichno- or tapho-) facies changes, condensation, stratigraphic gaps or hiatuses have been recorded. Structural complexity, synsedimentary and tectonic disturbances, or important alterations by metamorphism are not relevant constraints. 2) There is a well-preserved, abundant and diverse fossil record across the boundary interval, with key markers (ammonites and nannofossils) for worldwide correlation. The base of the Bathonian Stage and Zigzag Zone in Bas-Auran corresponds to the first occurrence level of *Gonolkites convergens* Buckman, which coincides with the first occurrence of *Morphoceras parvum* Wetzel. Calcareous nannofossils, as secondary global marker, are present in all beds and allow characterizing the Bajocian-Bathonian transition. 3) Regional analyses of sequence stratigraphy and manganese chemostratigraphy are available. Spectral gamma-ray data corroborate an Early Bathonian deepening half-cycle of second order. 4) The criteria of accessibility, conservation and protection are assured by the "Réserve Naturelle Géologique de Haute Provence". The Cabo Mondego Section (Portugal) is suggested as the Bathonian auxiliary section and point (ASSP) within this GSSP proposal.

Introduction

The present paper corresponds to part of the scientific dossier recently prepared by several specialists and sent to all members of the Bathonian Working Group (International Subcommission on Jurassic Stratigraphy, November 2007), in order to achieve the formal ballot on the selection and proposal of the Global Stratotype Section and Point (hereafter GSSP) for the Bathonian Stage (Fernández-López et al. 2007b). The following persons are members of the Bathonian Working Group: Alméras Y. (France), Bardhan S. (India), Bodergat A.M. (France), Callomon J.H. (UK), Cresta S. (Italy), Dietl G. (Germany), Dietze V. (Germany), Enay R. (France), Fernández-López S.R. (Spain), Galácz A. (Hungary), Hall R.L. (Canada), Henriques M.H. (Portugal), Hillebrandt A. von (Germany), Lanza R. (Italy), Mangold C. (France), Matyja B. (Poland), Meléndez G. (Spain), Mitta, V. (Russia), Mönnig, E. (Germany), Morton N. (France), Page K. (UK), Pandey D.K. (India), Pavia G. (Italy), Poulsen N. (Denmark), Poulton T.P. (Canada), Riccardi A.C. (Argentina), Rogov M.A. (Russia), Sandoval J. (Spain), Schlögl J. (Slovak Republic), Schweigert G. (Germany), Seyed-Emami K. (Iran), Wierzbowski A. (Poland), Yin J.-R. (China). The results of the vote (December 2007) has been as follows: Total BtWG members = 33, YES votes = 31 (93.4%), NO votes = 1 (3.03), ABSTAIN = 1 (3.03%), NO RESPONSE = 0.

The Bathonian Working Group (BtWG) was established in 1984, during the 1st International Symposium on Jurassic Stratigraphy in Erlangen, in order to improve the geologic data relative to the Bajocian/Bathonian boundary. The Bas-Auran section was first proposed as stratotype in a presentation to the Luxembourg II (1967) Colloquium by Torrens, but not published until 1974 (Morton 1974; Torrens 1974a, b, 1987, 2002). This section was formally proposed as a candidate for the basal boundary stratotype of the Bathonian Stage by Innocenti et

[1] Departamento y UEI de Paleontología, Facultad de Ciencias Geológicas (UCM) e Instituto de Geología Económica (CSIC-UCM), 28040-Madrid, Spain.
[2] Dipartimento di Scienze della Terra, via Valperga Caluso 35, 10125-Torino, Italy.
[3] Dipartimento di Scienze dalla Terra "Ardito Desio", Università degli Studi di Milano, Via Mangiagalli, 34, 20133-Milano, Italy.
[4] Centre de géologie – Parc Saint-Benoît, 04000-Digne les bains, France.
[5] Departamento Ciências da Terra e Centro de Geociências, Faculdade de Ciências e Tecnologia, Universidade de Coimbra, 3000-272 Coimbra, Portugal.
[6] Université Claude Bernard, Lyon-1, UFR des Sciences de la Terre et CNRS, UMR 5125, 27–43, bd du 11-Novembre-1918, 69622-Villeurbanne cedex, France.
*Corresponding author: Sixto R. Fernández-López. E-mail: sixto@geo.ucm.es

al. (1990) during the 2nd International Symposium on Jurassic Stratigraphy in Lisbon (1987). Over the following 20 years, several meetings have been organized by the Bathonian Working Group in Digne, La Palud, Budapest, Lyon and Torino. In the Bas-Auran area, the sections of Ravin du Bès, Ravin d'Auran and Ravin des Robines have been remeasured and recollected for taphonomic, sedimentologic and palaeoichnological analyses during 2006 and 2007. Reports from the Bathonian Working Group have been published by Mangold (from 1984 to 1999) and Fernández-López (from 2003 to 2007a) as mentioned in Fernández-López (2008). Over all the many years, no other candidate sections (besides Cabo Mondego) were judged worthy of consideration.

This dossier summarizes relevant results published by specialists, as well as comments and responses of the BtWG ballot 2007, in order to achieve the formal ballot on the proposal of the GSSP for the Bathonian Stage within the International Subcommission on Jurassic Stratigraphy.

Definition of the base of the Bathonian Stage (S.R. Fernández-López)

The Bathonian is the third of the four stages of the Middle Jurassic Series, above the Bajocian and below the Callovian. The name was introduced by d'Halloy (1843) and used as a stage by d'Orbigny (1850, pp. 607–608; 1852, pp. 491–492), derived from the "Bath Oolite", in the vicinity of the city of Bath (SW England). *Zigzagiceras zigzag* (D'ORBIGNY 1846, p. 390, pl. 129, figs. 9–10; Arkell 1958, p. 177, text-fig. 60, 1–3) and *Gonolkites convergens* BUCKMAN (1925, pl. 546 A-B; Arkell 1956, pl. 18, fig. 8; pl. 19, figs. 1–2) are the index species, respectively, of the Bathonian basal zone and subzone. The Zigzag Zone was distinguished from the underlying Parkinsoni Zone by Oppel (1857, p. 579, 1862), and later assigned to the "Bath-Gruppe" (Oppel 1865, p. 309) in a discussion of the section at "Montagne de Crussol" in the Ardèche (France). The Convergens Subzone was mentioned by Maubeuge (1950, p. 4), based on the "Convergens horizon" that was used in letters by Arkell (1951–59, p.10; 1956, p. 62). The Bajocian/Bathonian boundary established between the Parkinsoni and Zigzag zones was recommended at the two congresses denominated "Colloque du Jurassique" held in Luxembourg in 1962 (Rioult 1964; Torrens 1965) and 1967 (Torrens 1974a, b). The localities of Bath (England) and the "Montagne de Crussol" (France), however, have been considered quite unsuitable for a typological definition of the Bathonian Stage, because they are condensed sections with discontinuous and lenticular beds (Torrens 1974a, b, 2002; Page 1996b). After the publication of Sturani (1967), the base of bed 23 of the Bas-Auran section, in which *Gonolkites convergens* BUCKMAN, *Parkinsonia pachypleura* BUCKMAN and *Morphoceras parvum* WETZEL first appear, was designated as the type by which to define the base for the Convergens Subzone of the Zigzag Zone and the base of the Bathonian Stage by several authors (Morton 1974; Torrens 1974a, b, 1987; Harland et al. 1982). Later, there was general agreement among Bathonian specialists that the Bathonian Stage should start with the Standard Zigzag Zone, whose base is defined by the Convergens Subzone (Horizon 1 of Mangold 1984) followed by the Macrescens Subzone (Sturani 1967). The Parvum Subzone has been proposed by Mangold (1990) to denote the first Bathonian subzone of the Zigzag Zone in the Sub-Mediterranean Province, equivalent to the Convergens Subzone of the Northwest European Province and below the Macrescens Subzone. Analogously, due to palaeobiogeographical changes, the Dimorphitiformis Subzone has been proposed by Sandoval (1983) as the basal Bathonian subzone of the Zigzag Zone in the Mediterranean Province. Therefore, the position of the Bathonian basal boundary became justified by the base of the Northwest European Convergens Subzone of the Zigzag Zone remarkably well recorded in the Bas-Auran area, a place where both Convergens and Parvum subzones can be recognized and denote the rock bodies of the same stratigraphic interval (Fernández-López et al. 2007a; Pavia et al. 2008).

The Ravin du Bès Section (Bas-Auran area)

The Bas-Auran sections are located in southeastern France, in the French department "Alpes de Haute Provence", in the Chaudon-Norante commune, around 25 km to the South-Southeast of Digne-les-Bains (Fig. 1). Three sections have been selected in two ravines (Fig. 2). The first, the Ravin du Bès Section (RB), is located near the farm *l'Amata* (coordinates: 43º 57' 38" N, 6º 18' 55" E, altitude 730 m). The second, the Ravin d'Auran Section (RA), is located in front of the farm *Bas-Auran* (coordinates: 43º 57' 29" N, 6º 19' 00" E, altitude 790 m). The third one, the Ravin des Robines Section (RR), is just 400

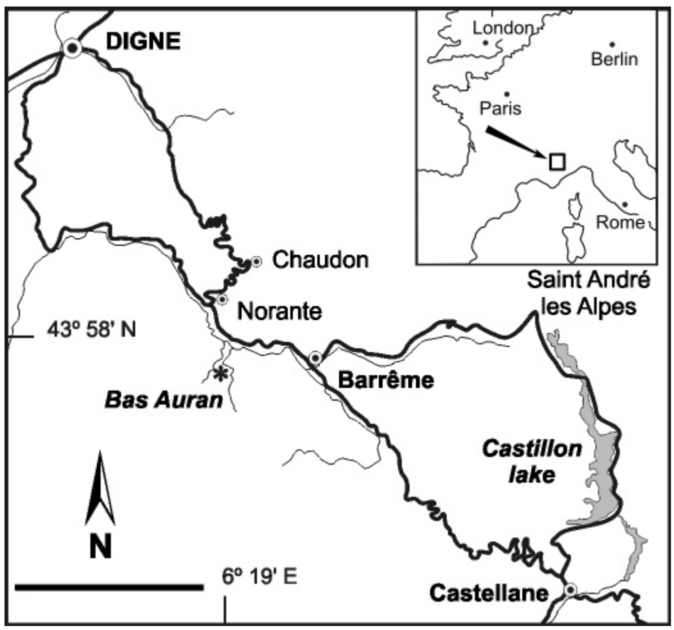

Fig. 1. Geographical setting of the Bas-Auran area (France). Scale bar is 10 km.

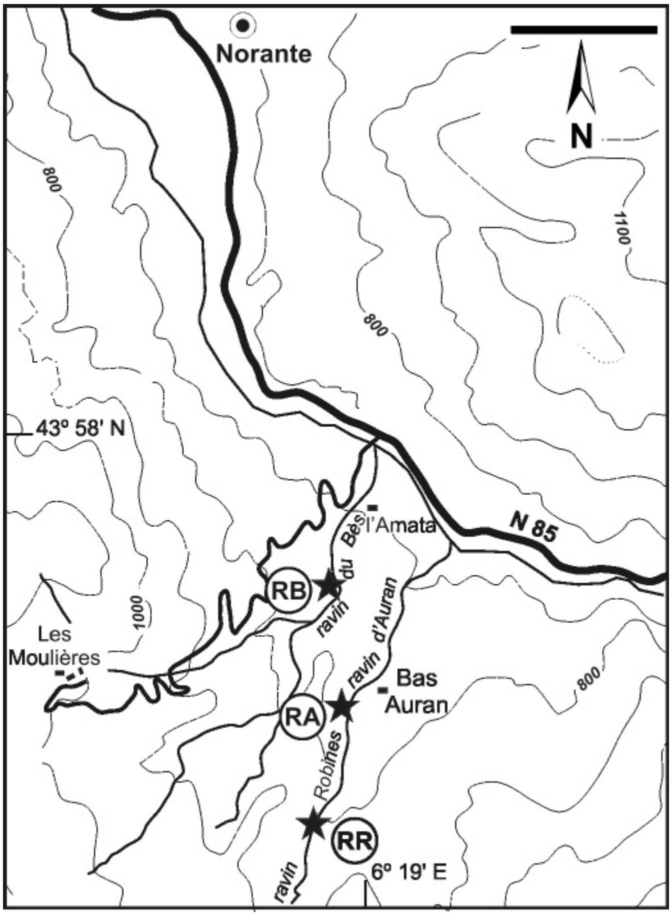

Fig. 2. Topographic sketch of the Bas-Auran area and location of the stratigraphic sections. Scale bar is 500 m. RB = Ravin du Bès Section. RA = Ravin d'Auran Section. RR = Ravin des Robins Section.

metres south of the RA section, along the Robines ravine (coordinates: 43º 57' 09" N, 6º 18' 50" E, altitude 830 m). They are located on the Castellane sheet of the "Carte géologique détaillée de la France" at the 1:80'000 scale (Goguel 1966) on the Digne sheet of the "Carte géologique de la France" at the 1:50'000 scale (Graciansky et al. 1982) and on the topographic sheet, scale 1:25'000, Barrême, no. IGN 3615.

These sections, which are free from significant disconformities, range from the Bomfordi Subzone (Parkinsoni Zone, Upper Bajocian) to the Tenuiplicatus Subzone (Aurigerus Zone, Lower Bathonian) and are over 13 m thick. Structural complexity, synsedimentary and tectonic disturbance, or considerable alterations by metamorphism, are not relevant constraints in the Bas-Auran area.

History of research on the Bathonian succession of the "Alpes de Haute Provence" and in particular of the Bas-Auran area (G. Pavia).

The area of Digne-Barrême was remarked by diverse authors as one of the most important in the world for establishing the ammonite zonal succession of the Bathonian Stage (Garnier 1872; Haug 1891, p. 80; Guillaume 1938; Arkell 1956, p.149). The Bas-Auran locality was firstly mentioned by Haug (1891) and later visited by the French Geological Society (Zürcher 1895). Sturani in 1967 published a detailed study of the Bajocian-Bathonian succession with a litho- and biostratigraphical log settled from the whole outcrops of the Bas-Auran area. A partial revision of Sturani's work was produced by Torrens (1987) mainly on the Tenuiplicatus Subzone at the uppermost part of the marly-calcareous succession. Contribution on the lowermost Bathonian beds was finally presented by Innocenti et al. (1990) that inserted in Sturani's log the new material derived from fieldwork during ten years. More recent samplings, mainly concentrated on poorly documented and critical intervals, enlarged the Bas-Auran database from the Zigzag Zone, and furnished new and complementary results on the taphonomy of the ammonoid fossil-assemblages (Fernández-López 2007b), as well as on the taxonomy and phylogenetic arrangement of the Bathonian Bigotitinae and the origin of Zigzagiceratinae (Fernández-López et al. 2007a). Recently, Pavia et al. (2008), suggested: 1) to describe the successive ammonoid assemblages of the uppermost Bajocian to lowermost Bathonian in the Bas-Auran area, 2) to refine the subzonal biostratigraphic subdivision of the marly-calcareous succession, 3) to characterize the ammonoid content at the very base of the Zigzag Zone, 4) to demonstrate the general continuity of the ammonoid succession, and 5) to attest the suitability of one of those sections to be selected as the GSSP of the Bathonian Stage.

Geological setting of the marly-calcareous succession from the Bajocian to Bathonian in the Digne area (D. Olivero & G. Pavia)

The studied area is located in the French Subalpine Basin (FSB), corresponding to a gulf on the northwestern margin of the Tethyan Ocean (Fig. 3).

The basin is bordered by the "Massif Central" on the West and the Alpine Chain on the East (Fig. 4). During Middle Jurassic time, the basin margin was characterized by a network of tilted blocks similar to the present margin of the Atlantic Ocean (Lemoine 1984, 1985). The maximum depth of the central part of the basin probably was about 700–800 metres (Ferry 1990). The region was a transitional area between the epicontinental sea of the Paris Basin and the deep Piedmont oceanic domain, on the continental slope of the French Subalpine Basin. The studied succession is a cyclic marl-limestone alternation. In most previous works and on the geological map of Digne (Graciansky et al. 1982; Olivero & Atrops 1996) it was described as the "Calcaires à *Cancellophycus*" Formation which, in the studied region, ranges from Aalenian to Bathonian and is covered by the "Terres Noires" Formation (Late Bathonian to Oxfordian). The "Calcaires à *Cancellophycus*" Formation should not be mistaken for the partially coeval "Calcaires à *Zoophycos* du Verdon" Forma-

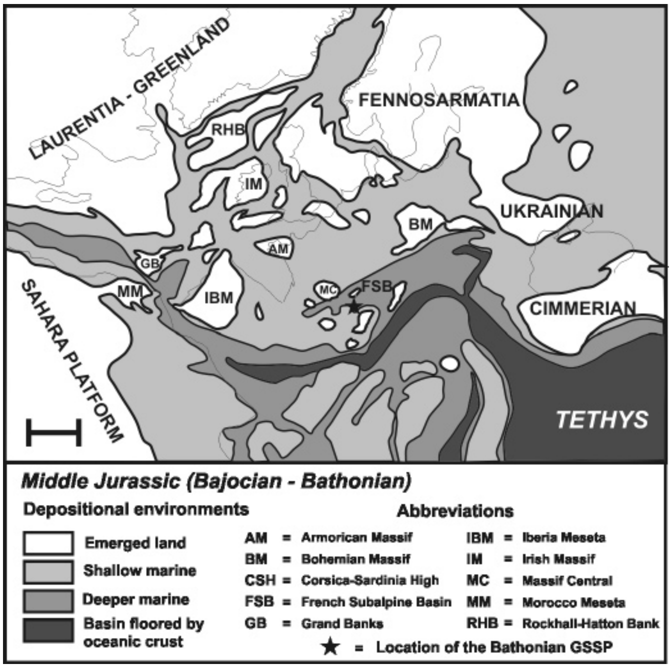

Fig. 3. The northwestern margin of the Tethyan Ocean, with the location of the French Subalpine Basin (modified from Ziegler 1988). Scale bar is 500 km.

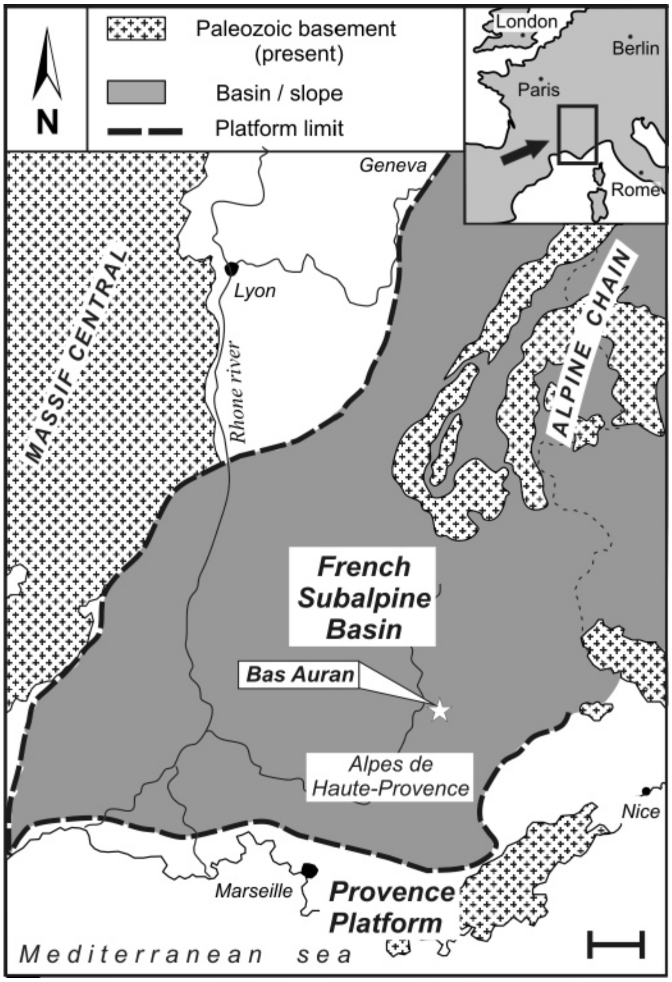

Fig. 4. The French Subalpine Basin, with the location of the Bas-Auran area (from Olivero 2003, modified). Scale bar is 25 km.

tion, Lower Bathonian to Middle Callovian in age, proposed by Olivero and Atrops (1996) in the southernmost transitional area, between the Subalpine Basin and the Provence Platform.

Palaeoichnology, taphonomy, sedimentology and sequence stratigraphy of the upper Bajocian to lower Bathonian of the Bas-Auran area (S.R. Fernández-López & D. Olivero)

In the Bas-Auran area, Lower Bathonian deposits comprise black or grey limestone beds alternating with marls usually known as "Marno-calcaires à *Cancellophycus*" (Graciansky et al. 1982; Olivero & Atrops 1996). Petrographically and in terms of biofacies, these deposits are relatively uniform mudstones to wackestones, with common ammonoids, scarce sponges and very scarce nautiloids, brachiopods, bivalves, belemnites, echinoids, crinoids and gastropods. As to microfossils, the overall sedimentary facies shows a calcisphere-mudstone texture; the marls contain foraminifers (*Lenticulina*, *Dentalina*), ostracods and molluscs (cephalopods, bivalves, gastropods) along with detrital minerals, quartz, muscovite and biotite (Corbin et al. 2000).

Palaeoichnological studies have been carried out by Olivero (1994, 2003). Bioturbation textures are common and bioturbation structures are scarce, indicating dominant softgrounds. *Zoophycos*, *Chondrites* and *Planolites* occur from the bed RB093 to bed RB001 (Fig. 5). Local concentrations of trace fossils of these ichnotaxa in bed RB039 suggest the development of a soft- to firmground in this stratigraphic level (Fig. 5). Bioturbation structures indicative of firmground (*Thalassinoides*, *Rhizocorallium*, *Zoophycos* and trace fossils related to large *Halimedides*) occur in a more calcareous layer just overlying the top of the bed RB003. Biogenic borings indicative of hardground (*Zapfella*) are common, associated with very scarce encrusting serpulids, on the top of bed RB001, indicating the exceptional development of a stratigraphic discontinuity at the top of the "Marno-calcaires à *Cancellophycus*" on the Bas-Auran area. Sedimentation appears irregular and condensed from bed RB093 towards the top of the Bathonian Zigzag Zone, compared with previous intervals where a more constant and expanded sedimentation is suggested. At the Bajocian-Bathonian transition, however, no stratigraphic gaps or hiatuses have been recorded. From a taphonomic point of view, the occurrence of resedimented and reelaborated ammonoids implies that some form of current flow or winnowing affected the burial of concretionary internal moulds. Ammonoids show the following taphonomic characters at the Bajocian-Bathonian transition: 1) high values of stratigraphic persistence of ammonoid shells, 2) dominance of homogeneous concretionary internal moulds of phragmocones, completely filled with sediment, and 3) dominance of unflattened sedimentary moulds bearing no signs of rounding, bioerosion or dense encrusting by organisms (such as serpulids, bryozoans or oysters). These taphonomic features are indicative of a low rate of sedimentation and a low rate of accumulation of sediment, associated with sedimentary starvation in deep environments (Fernández-López 2007a).

The bed-scale limestone-marl alternation is primary in origin, although accentuated by diagenetic redistribution of carbonate. Lithological differentiation between marly and limestone intervals resulted from alternating episodes of carbonate input and starvation. Both lithologies may contain evidence of sedimentary and taphonomic reworking, associated with scours, which reflect low rates of sedimentation and stratigraphic condensation. There is no evidence, however, of taphonomic condensation (i.e. mixture of fossils of different age or different chronostratigraphic units) in the ammonoid fossil-assemblages, except in level 002. Sedimentological data and sequence-stratigraphy interpretations of the Jurassic deposits in the French Subalpine Basin have been published by Graciansky et al. (1993, 1998a, b), Olivero & Atrops 1996, Olivero et al. (1997), Hardenbol et al. (1998) and Jacquin et al. (1998).

Palaeoichnological, taphonomic and sedimentological results confirm, therefore, the development of a deepening phase associated with sedimentary starvation, within 3rd and 2nd order cycles, in the Bas-Auran area, during the Early Bathonian. The maximum deepening of a 2nd-order transgressive/regressive facies cycle (T/R 7, Upper Aalenian–Upper Bathonian, in Graciansky et al. 1993, 1998 a, b) is at the end of the Early Bathonian, which corresponds to an extensional and deepening phase of the basin. The outcrop successions at Bas-Auran show no obvious signs of non-sequence or discontinuity across the Bajocian/Bathonian boundary interval.

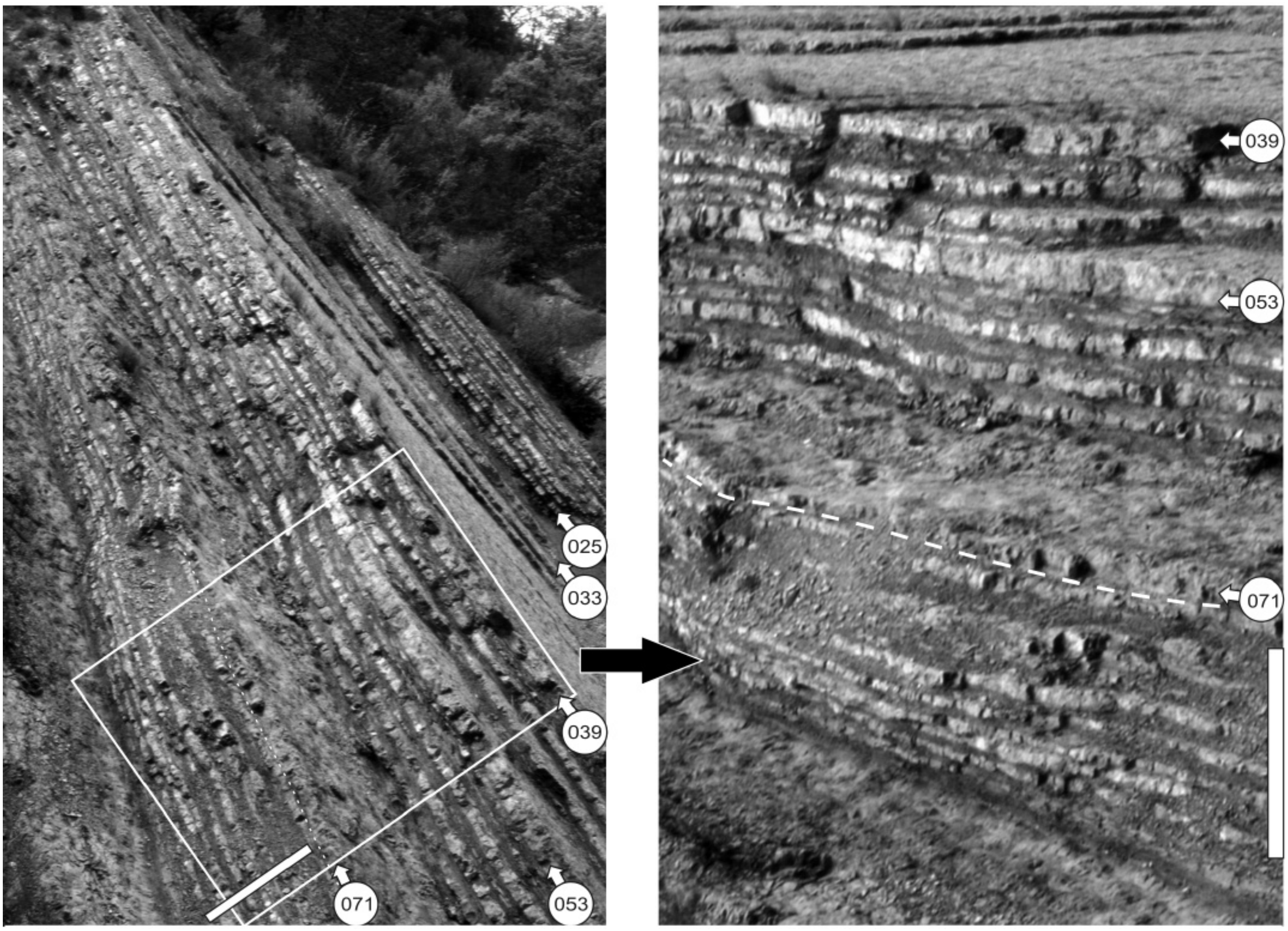

Fig. 5. Ravin du Bès Section and detail of beds around the Bajocian/Bathonian boundary interval. Limestone bed 071 indicates the base of the Bathonian. Scale bar is 1 m.

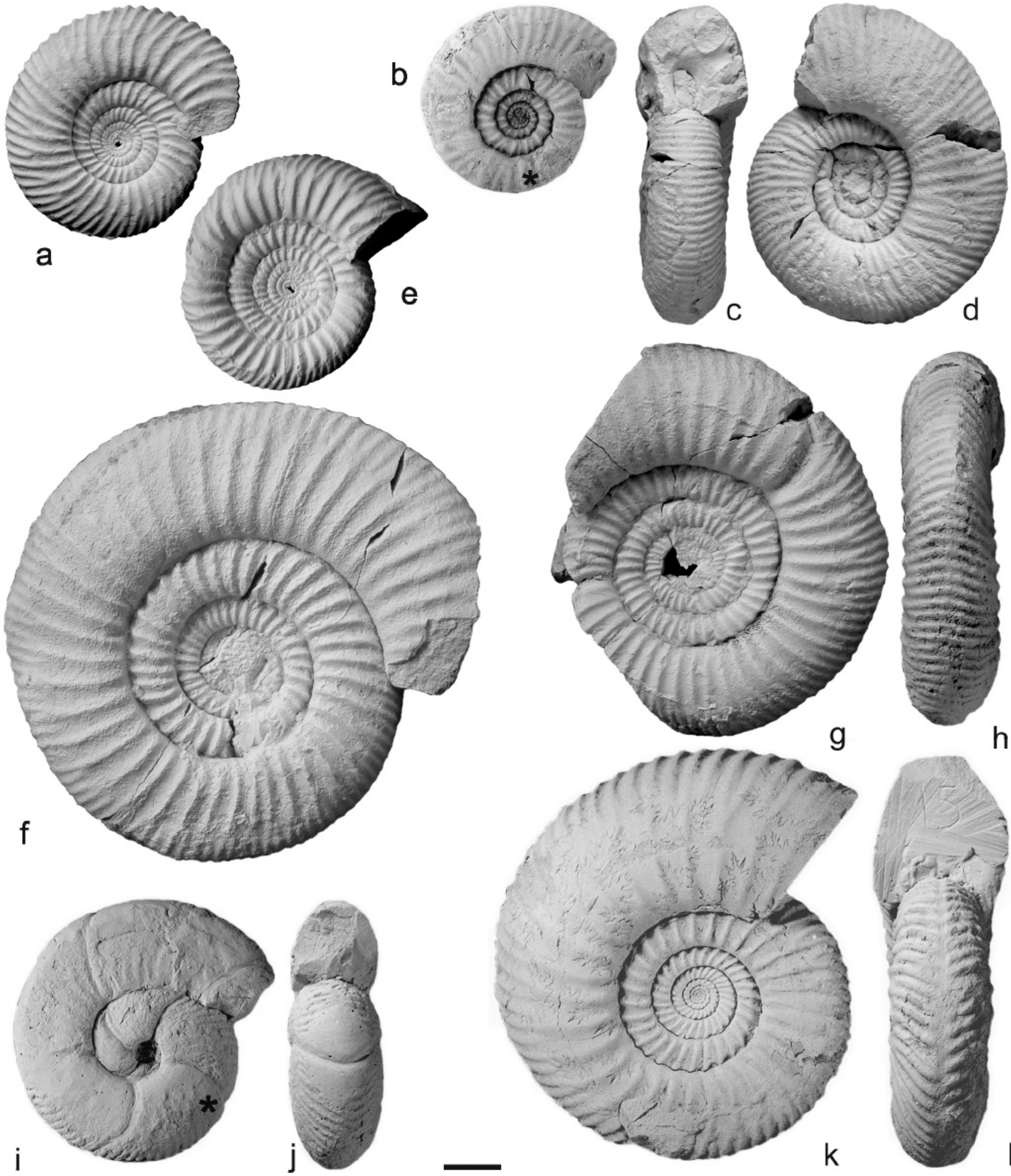

Fig. 6. Lower Bathonian ammonites from Bas-Auran area. Specimens have been whitened with magnesium oxide prior to photography. Scale bar is 1 cm. (a): *Bigotites mondegoensis* FERNÁNDEZ-LÓPEZ et al. [M], specimen PU111312, level BA14, Convergens Subzone. (b): *Protozigzagiceras* cf. *torrensi* (STURANI) [m], specimen PU111573, level RA033 (= BA12), Macrescens Subzone. Black asterisk marks the last septum of the phragmocone. (c, d): *Protozigzagiceras* aff. *torrensi* (STURANI) [M], specimen PU31694, level BA13, Convergens Subzone. (e): *Bigotites sturanii* FERNÁNDEZ-LÓPEZ et al. [M], specimen PU111253, level BA19, Convergens Subzone. (f): *Bigotites diniensis* STURANI [m], specimen PU111243, level BA20, Convergens Subzone. (g, h): *Bigotites sturanii* FERNÁNDEZ-LÓPEZ et al. [M], specimen PU111233, level BA20, Convergens Subzone. (i, j): *Morphoceras parvum* WETZEL [M], specimen PU111564, level BA17, Convergens Subzone. Black asterisk marks the last septum of the phragmocone. (k, l): *Gonolkites convergens* BUCKMAN [M], specimen PU111067, level BA15, Convergens Subzone.

Palaeontological records

The Bomfordi and Convergens subzones in the Bas-Auran area contain an ammonoid succession that displays a maximum value of biostratigraphic and biochronostratigraphic completeness. Additional macrofossil groups occur in the sections (e. g., sponges, bivalves, brachiopods and belemnites), although they are scarce and have not yet been studied in detail.

Ammonites (S.R. Fernández-López, C. Mangold & G. Pavia)

Biochronostratigraphic data on ammonoids of the Bas-Auran sections have been published by Sturani (1967), Pavia (1973, 1983a, b, 1984, 1994, 2000, 2007), Torrens (1987), Innocenti et al. (1990), Olivero et al. (1997) and Joly (2000). New and complementary results from the biochronostratigraphic analyses of ammonoid fossil-assemblages at the Bajocian/Bathonian boundary in Bas-Auran are in press (Fig. 6, Fernández-López et al. 2007a, Pavia et al. 2008). In the French Subalpine Basin, the successive ammonoid fossil-assemblages are composed of Mediterranean and Northwest European representatives, associated with some Sub-Mediterranean ones. Upper Bajocian and Lower Bathonian Mediterranean taxa of the suborders Phylloceratina and Lytoceratina are relatively common (up to 25% at subzonal scale, Fig. 7). Northwest European taxa, such as Parkinsoniinae, may surpass 25% at subzonal scale. Lower Bathonian Bigotitinae, endemic and characteristic of the Sub-Mediterranean Province, reach 13%. This complex palaeobiogeographical pattern of the Upper Bajocian and Lower Bathonian ammonoid fossil-assemblages enables recognition of diverse subzonal schemes and accurate chronocorrelation between the three main provinces of the West Tethyan Subrealm.

Among the possible guide fossils for the Bajocian/Bathonian boundary, Parkinsoniidae have a better record than Morphoceratidae. The lowest occurrences of *Gonolkites* [M] and *Morphoceras* [M] may be evidence of palaeobiological events, i.e., of origination of *Gonolkites* (from a species of *Parkinsonia*) and immigration of *Morphoceras*. The base of the Bathonian and the Zigzag Zone corresponds to the first occurrence level of *Gonolkites convergens* and the renewal of parkinsonids at the base of limestone bed RB071 (bed 23 in Sturani 1967) in the Ravin du Bès Section (Fig. 8). Additionally, the base of the Bathonian in Bas-Auran sections coincides with the lowest occurrence of *Morphoceras parvum*. Furthermore, the bases of the Northwest European primary standard Convergens Subzone and the Sub-Mediterranean secondary standard Parvum Subzone are in fact precisely coeval in the Bas-Auran area.

New palaeontological data about the youngest members of Bigotitinae and the oldest members of Zigzagiceratinae are of biochronostratigraphic importance for the subdivision and correlation of the basal Bathonian Zigzag Zone. Three successive biohorizons have been identified and chronocorrelated between the Bas-Auran (French Subalpine Basin) and Cabo Mondego (Lusitanian Basin) successions: Diniensis, Mondegoensis and Protozigzagiceras biohorizons (Fernández-López et al. 2007a; Pavia et al. 2008). The Diniensis Biohorizon is characterized by the occurrence of *Bigotites diniensis* representatives and it corresponds to the lowest part of the Bathonian Zigzag Zone in the Sub-Mediterranean Province (e.g., Cabo Mondego and Bas-Auran). It encompasses the stratigraphic interval RB071–RB054 (Fig. 8, levels 23–18 of Sturani 1967) in Ravin du Bès Section. The Mondegoensis Biohorizon is defined by the lowest occurrence of *Bigotites mondegoensis* representatives. It comprises the stratigraphic interval RB053–RB034 (Fig. 8, levels 17–14 of Sturani 1967) in Ravin du Bès Section. The Protozigzagiceras Biohorizon is defined by the lowest oc-

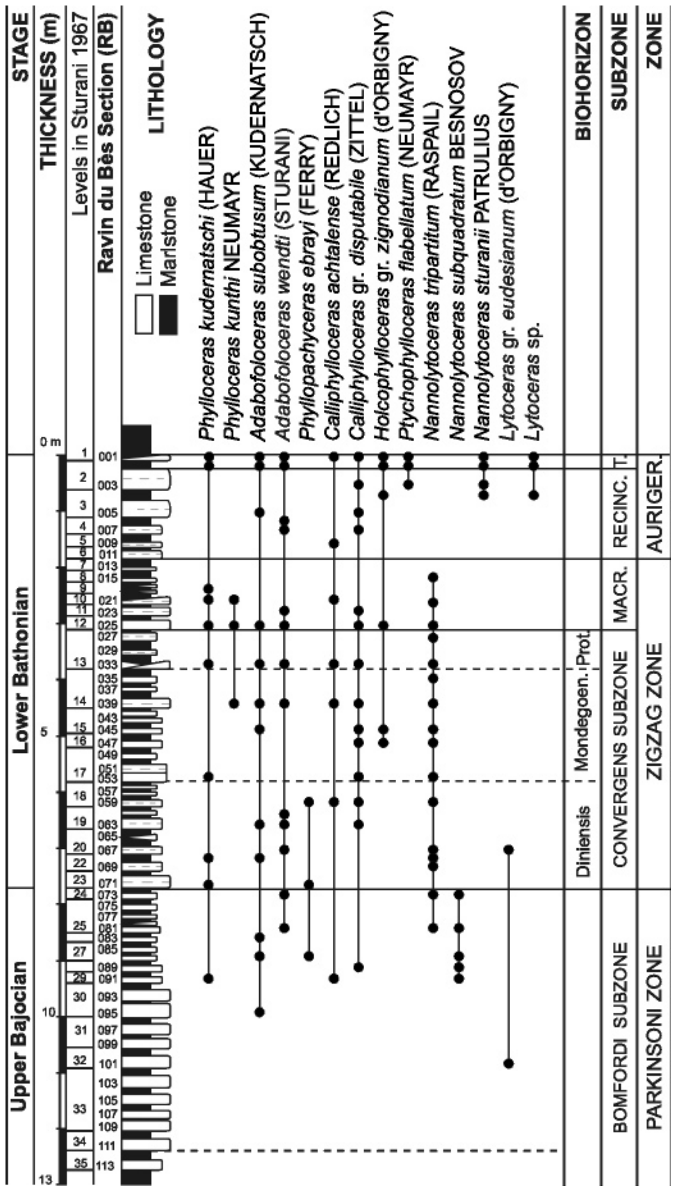

Fig. 7. Phylloceratina and Lytoceratina biochronostratigraphic data at the Bajocian/Bathonian boundary in the Ravin du Bès Section (from Pavia et al. 2008).

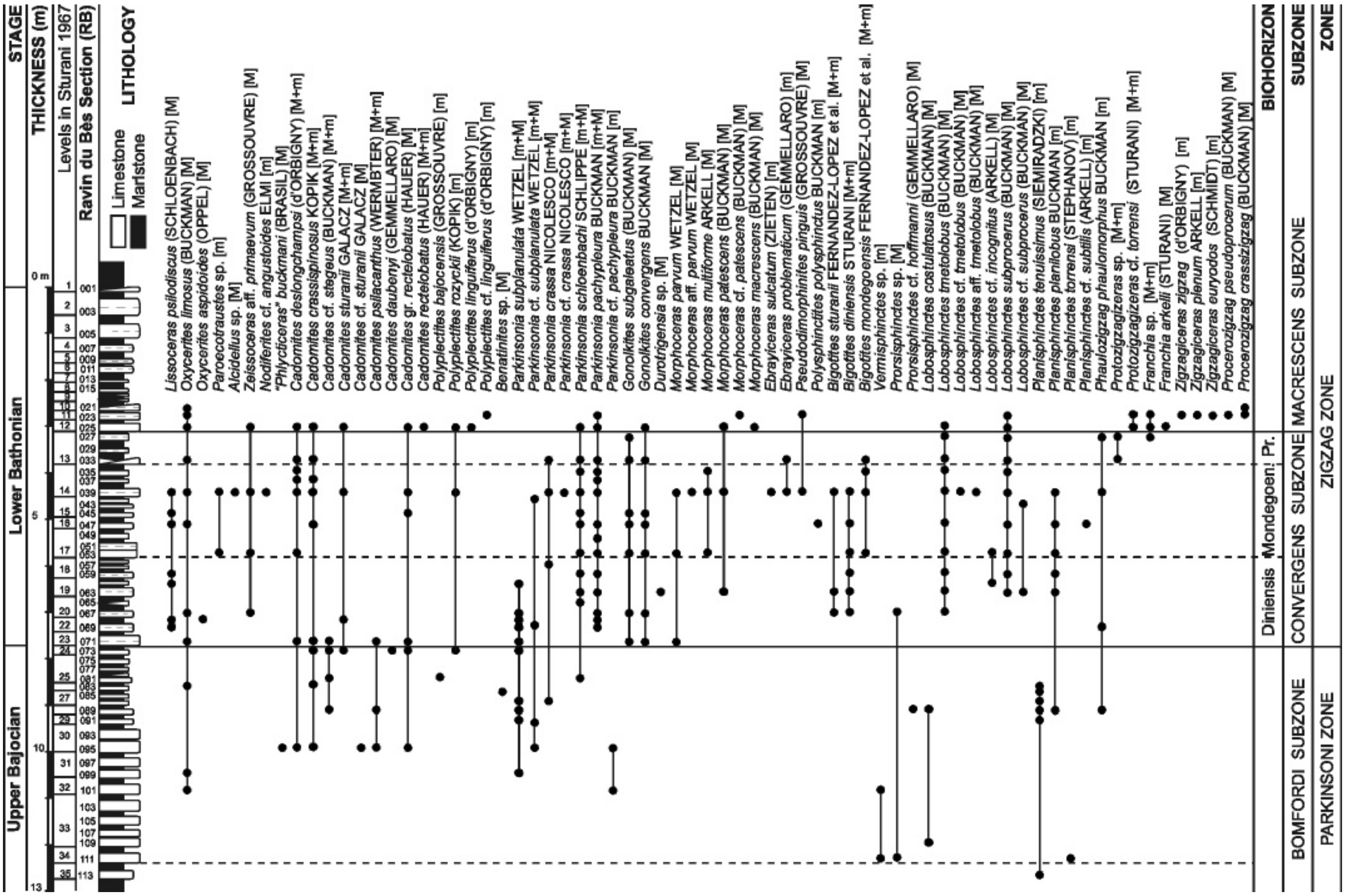

Fig. 8. Ammonitina biochronostratigraphic data at the Bajocian/Bathonian boundary in the Ravin du Bès Section (from Pavia et al. 2008).

currence of Zigzagiceratinae representatives, in particular *Protozigzagiceras* [M + m] and *Franchia* [M + m]. It encompasses the stratigraphic interval RB033–RB026 (level 13 of Sturani 1967) in Ravin du Bès Section.

According to Pavia et al. (2008), the record quality of the ammonoid biostratigraphic succession in the Bas-Auran area can be tested with various palaeontological criteria: the preservation state of fossil-specimens, taphonic populations and fossil-assemblages; abundance, concentration, packing and stratigraphic persistence of fossil-specimens; completeness, constancy and persistence of stratigraphic ranges; completeness and taxonomic diversity of successive fossil-assemblages; biostratigraphic turnover; proportion of virtual and actual palaeontological gaps in successive stratigraphic intervals; proportion of first and last occurrences of taxa; proportion of lowest and highest occurrences of taxa; successive or coincident clustering of last and first occurrences. Values of these twenty-one palaeontological attributes indicate a relatively homogeneous and good record quality, gradual biostratigraphic change and high degree of taxonomic similarity between the Bomfordi and Convergens subzones. These criteria, applied to the ammonoid genera which are known from the Bas-Auran area, also indicate relatively high values of palaeontological and stratigraphic completeness at the base of levels RB070–RB071 (= level 23 in Sturani 1967; i.e., the Bajocian/Bathonian boundary). The ammonoid biostratigraphic succession of Bas-Auran shows no evidence of biochronostratigraphic mixing, taphonomic condensation, signs of non-sequence or biostratigraphic discontinuities across the Bajocian/Bathonian boundary interval. Moreover, with forty-six successive ammonoid fossil-assemblages of the Convergens Subzone, along up to 5 metres of thickness belonging to three biohorizons, the Ravin du Bès Section displays maximum values of biostratigraphic and biochronostratigraphic completeness.

Microfossils

The Bajocian/Bathonian boundary may be characterized by secondary (auxiliary) biostratigraphic markers, such as nannofossils. According to the results of Erba (1990a, b; Cobianchi et al. 1992; Mattioli & Erba 1999), calcareous nannofossils are present in all beds and facilitate the characterization of the Bajocian-Bathonian transition. The Ravin du Bès Section appears to be suitable for the biostratigraphical study of microfossils, such as foraminifers or ostracods, but there are at present no published studies. According to preliminary results (Bodergat in Mangold 1999), ostracods are present in all marly samples, but are badly preserved between bed RB071 and bed RB033. The marine taxa are different from those known in the Paris Basin and England. The Subalpine taxa, specially the genera *Pontocyprella*, *Isobythocypris* and *Cordobairdia*, indicate deeper environments (more than 200 m). Palynomorphs are poorly preserved and are not yet stratigraphically useful across the boundary (Poulsen 1997; Mangold 1999).

Calcareous nannofossils (E. Erba & D. Tiraboschi)

Nannofossil biostratigraphic investigation was performed on 59 samples (approximately every 20 cm) collected from the Ravin du Bès section in the Bas-Auran area; sample figures correspond to the bed numbers of the lithostratigraphic column of Figures 7 and 8. This study is a revision of the previous work by Erba (1990a, b), extended to limestone layers and additional marlstone beds. Simple smear slides were prepared for both limestone and marlstone, using standard techniques without concentration by centrifuging cleaning in order to retain the original sediment composition. A few milligrams of powdered sediments were mounted on a glass slide with the Norland Optical Adhesive, and then analyzed using a polarizing light microscope, at 1250x magnification.

All studied samples contain calcareous nannofossils. A total of 37 taxa were identified and their distribution is given in Figure 9. The nannofossil total abundance fluctuates from extremely rare to common; the preservation is poor to moderate, with evidence of dissolution and overgrowth. Limestone levels generally contain depauperated and poorly preserved nannofloras, with stronger overgrowth and dissolution.

The nannofloras are characteristic of the Upper Bajocian–Lower Bathonian interval. Assemblages are dominated by *Watznaueria britannica* and *Watznaueria communis*, with common *Schizosphaerella punctulata*, *Watznaueria* aff. *W. manivitiae*, *Watznaueria manivitiae*, *Cyclagelosphaera margerelii*, *Cyclagelosphaera deflandrei*, *Lotharingius crucicentralis*, *Lotharingius velatus*, *Lotharingius sigillatus* and *Ethmorhabdus gallicus*.

Based on absence of *Carinolithus superbus* and of *Watznaueria barnesiae*, the lowermost portion of the investigated interval (samples 110 through 68b) corresponds to the Tethyan *W. communis* Subzone (NJT 10b) indicating a Late Bajocian age (Mattioli & Erba 1999). This subzone corresponds to the upper part of the Boreal NJ 10 Zone and the lower part of the NJ 11 Zone of Bown & Cooper (1998). The first occurrence (FO) of *Pseudoconus enigma* in sample 89 identifies the NJ10/NJ11 zonal boundary (Figs. 10–11). This taxon is rare and occurs only in limestones, with the only exception of a single specimen in marlstone sample 20, and this is why Erba (1990b) did not report this species.

The last occurrence (LO) of *Hexalithus magharensis* was observed in sample 82 indicating a latest Bajocian age (Mattioli & Erba 1999). Similarly, Erba (1990b) recorded this event in the Parkinsoni Zone (latest Bajocian) of the Digne area, whereas in Portugal and Morocco de Kaenel et al. (1996) found an older age for the LO of *H. magharensis*, calibrated between the end of the Early Bajocian and the beginning of the Late Bajocian.

The FO of *Stephanolithion speciosum octum* was observed in sample 76; the taxon is extremely rare and scarce in the studied section. This event has been correlated to the base of the Parkinsoni Zone in NW Europe and Portugal (de Kaenel et al. 1996), but within the Zigzag Zone in SE France (Erba 1990b). Bown et al. (1988) and Bown & Cooper (1998) report the FO of *S. speciosum octum* at the base of the Boreal NJ 11 Zone.

The FO of *W. barnesiae* (NJT11) was observed in sample 68a of earliest Bathonian age (Zigzag Zone). This event defines the base of the Tethyan NJT11 Zone (Mattioli & Erba 1999), comparable to most of the Boreal NJ11 Zone and NJ12a Subzone (Bown et al. 1988, Bown & Cooper 1998).

The uppermost portion of the studied interval corresponds to the Tethyan NJT 11 Zone (Mattioli & Erba 1999), since *Cyclagelosphaera wiedmannii* was not observed.

From sample 89 upwards, rosette-shaped specimens similar to the genus *Rucinolithus* were consistently observed. They show highest abundance in the interval between sample 45 through 22 (Fig. 9), both in limestone and marlstone beds. Two morphotypes were distinguished, namely small (<8 microns) and large (>8 microns) *Rucinolithus* spp., based on their diameter. More detailed investigations are in progress to characterize the taxonomy of these morphotypes (Tiraboschi & Erba in prep.).

Our results are consistent with previous biostratigraphic data from the Upper Bajocian–Lower Bathonian interval in SE France (Erba 1990b), Portugal, NW Europe (de Kaenel & Bergen 1993, de Kaenel et al. 1996), Lombardian Basin (Chiari et al. 2007) and Boreal Realm (Bown & Cooper 1998). For the first time *P. enigma* has been documented from mid to low latitudes allowing a direct calibration between Tethyan and Boreal nannofossil events and biozones (Fig. 10).

Correlation (S.R. Fernández-López)

Ammonites are the most relevant taxonomic group for global biochronostratigraphic correlation of the Bajocian/Bathonian boundary. Nevertheless, diverse taxonomic groups of macroinvertebrates and microfossils are also of biochronostratigraphic relevance.

Ammonites

Late Bajocian and Early Bathonian ammonites are found worldwide in the three major, oceanic or marine, palaeogeographical units: Tethyan, Pacific and Boreal domains or realms (Cariou et al. 1985; Hillebrandt et al. 1992a, b; Taylor et al. 1992; Westermann 1993a, 2000; Page 1996a; Enay & Cariou 1999; Moyne & Neige 2007). The most difficult problem in biochronocorrelation of the boundary is not the low biostratigraphic

Lithology	Samples	Total abundance	Preservation	*Watznaueria communis* Reinhardt	*Watznaueria britannica* (Stradner) Reinhardt	*Watznaueria fossacincta* (Black) Bown in Bown & Cooper	*Watznaueria contracta* (Bown & Cooper) Cobianchi et al.	*Watznaueria* aff. *W. manivitiae* Cobianchi et al.	*Watznaueria manivitiae* Bukry	*Hexalithus magharensis* Moshkovitz & Ehrlich	*Lotharingius hauffii* Grün and Zweili in Grün et al.	*Cyclagelosphaera margerelii* Noël	*Cyclagelosphaera deflandrei* (Manivit) Roth	*Diazomatolithus lehmanii* Noël	*Zeugrhabdotus erectus* (Deflandre in Deflandre & Fert) Reinhardt	*Discorhabdus* sp.	*Schizosphaerella punctulata* Deflandre & Dangeard	*Triscutum* sp.	*Tubirhabdus patulus* Prins ex Rood et al.	*Watznaueria* aff. *W. contracta* Cobianchi et al.	*Lotharingius sigillatus* (Stradner 1961) Prins in Grün et al.	*Lotharingius velatus* Bown and Cooper	*Ethmorhabdus gallicus* Noël	*Lotharingius crucicentralis* (Medd) Grün and Zweili	*Tetralithus* sp.	*Lotharingius barozii* Noël	*Watznaueria* aff. *W. barnesiae* – with central area not completely closed	*Hexalithus hexalithus* Noël	small *Rucinolithus* sp.	large *Rucinolithus* sp.	*Pseudoconus enigma* Bown & Cooper	*Zeughrabdotus* sp.	*Stephanolithion speciosum octum* Rood & Barnard	*Hexapodorhabdus cuvillieri* Noël	*Watznaueria barnesiae* (Black in Black & Barnes) Perch-Nielsen	*Discorhabdus striatus* Moshkovitz & Ehrlich	*Biscutum* sp.	*Truncatoscaphus hexaporus* Moshkovitz & Ehrlich	*Crepidolithus crassus* (Deflandre in Deflandre & Fert) Noël	*Stephanolithion speciosum speciosum* Deflandre in Deflandre & Fert	Nannofossil Zones and Subzones (Tethyan)	Nannofossil Zones (Boreal)	Ammonite Zones	Stages
Limestone	1	FC	PM	R	R			R	R			R	R		R		R													R					R						*W. barnesiae* NJT11	*P. enigma* NJ11	*Aurigerus Z.*	Lower Bathonian
Limestone	3a	F	P	F	F			R	R			R					R												R		R													
Limestone	3b	R	P	R	R																								R	R														
Marlstone	4	FC	PM	F	F			R	R				R	R			R	R					R	R			R	R				R		R	R	R	R	R		R				
Limestone	5	R	P	R	R												R													R														
Marlstone	6	FC	PM	F	F								R				R						R		R		R		R						R									
Limestone	7	R	P	R	R			R	R																				R		R				R									
Marlstone	8	FC	PM	FC	FC							R			R		R			R	R	R	R		R		RF		R	R			R		R	R	R							
Limestone	9	R	P	R	R												R																											
Marlstone	10	FC	PM	FC	FC				R			R	R				R					R		R			R		R	R					R		R			R				
Marlstone	12	F	PM	RF	RF			R	R		R	R	R									R					RF	R	R						R				R				*Zigzag Zone*	
Limestone	13	R	P	R	R												R												R		R													
Marlstone	14	R	P	R	RF																		R				R		R						R									
Marlstone	16	R	P	RF	RF												R	R									RF		R															
Marlstone	20	FC	PM	RF	RF		R	R	R						R		R			R	R		R	R	R		RF		R	R	R		R		R	R	R							
Limestone	21	R	P	F	F												R										R	R	R	R	R													
Marlstone	22	FC	PM	F	F		R		R					R			R		R		R		R	RF		R	RF		RF	RF							R		R	R				
Limestone	23	R	P	R	R																								R	R	R									R				
Marlstone	24	FC	PM	FC	F			R	R			R	R	R			R								R	R	R		RF	RF					R									
Limestone	25	R	P	F	F												R												R	R	R													
Marlstone	26	FC	PM	FC	F			R							R		R						R	R	R		RF		R	R								R						
Limestone	31	R	P	R	R				R								R												R	R	R													
Marlstone	34	F	P	F	F			R	R												R		R		R	R			RF	RF							R							
Limestone	35	R	P	R	R	R																							R															
Limestone	39	RF	P	F	F				R																			R	R	R	R													
Marlstone	40	F	P	F	F		R		R			R	R				R				R	R	R		R		R		RF	RF			R				R							
Limestone	45	RF	P	F	F			R															R						RF	RF	R													
Marlstone	46	F	P	F	F							R					R				R		R		R		R	R	R															
Limestone	47	RF	P	F	F				R								R												R	R	R													
Marlstone	48	FC	PM	FC	C				FC			R	R				R			R		R		R	R	R			R	R			R		R				R					
Limestone	51	RF	P	F	F				R								R												R	R	R													
Limestone	53	RF	P	F	F			R									R												R	R	R													
Limestone	55	R	P														R												R															
Marlstone	60	C	M	FC	C			R	R		R	R	R		R	R	R	R			R			R	R	R	R		R	R					R	R	R	R						
Limestone	63	RF	P	FC	C			R	R								R								R		R	R																
Marlstone	64	FC	PM	FC	C			R				R				R	R		R		R	R			R	R			R				R											
Limestone	67	R	P	R	R				R								R											R	R	R	R													
Marlstone	68a	C	PM	FC	C			R					R			R	R							R				R	R	R					**R**									
Marlstone	68b	C	PM	C	A			R							R		R				R		R		R		R		R												*W. communis* NJT10b			
Limestone	69	R	P	R	R												R										R		R															
Limestone	71a	R	P	R	R																								R															
Limestone	71	R	P	R	R			R									R												R															
Limestone	71b	F	P	F	F		R					R					R										R	R	R	R				R										
Marlstone	72	C	M	C	A			R	R			R					R		R	R	R	R	R	R	R		R		R														*Parkinsoni Zone*	Upper Bajocian
Limestone	73	R	P	F	F	R		R			R						R						R						R		R													
Marlstone	74	C	PM	C	A		R	RF	R				R				R			R		R	R	R			R		R															
Marlstone	76	C	M	C	A			R			R	R	R	R	R						R		R	R	R	R		R	R	R	R		R	**R**										
Marlstone	82	C	PM	C	A		R	R		R	R	R				R	R				R	R						R	R	R														
Limestone	83	R	P	F	F							R					R												R	R														
Marlstone	84	C	M	C	A		R	RF			R	R	R				R				R	R	R	R	R		R	R																
Limestone	85	F	PM	FC	F	R	R	R					R				R			R				R	R				R	R	R													
Marlstone	86	FC	P	FC	C		R	R									R							R	R																			
Limestone	89	F	P	F	F	R			R			R	R				R								R			R	R	R	**R**													
Marlstone	90	C	PM	C	A	R	R	R		R	R					R	R	R		R	R				R	R	R	R														NJ10		
Marlstone	92	C	PM	C	A	R		R		R			R				RF			R			R	R																				
Limestone	93	FC	P	F	F												R									R																		
Marlstone	96	C	PM	C	A		R	RF		R		R		R			RF					R		R	R																			
Marlstone	100	C	PM	C	A	R	R	R		R			R				R		R	R	R	R		R																				
Marlstone	102	C	PM	C	A	R	R	RF		R	R	R		R	R		RF		R	R	R	RF	RF																					
Marlstone	110	C	PM	C	A	RF	RF	F	R	R	R	R	R	R	R	R	RF	R	R																									

Fig. 9. Chart of calcareous nannofossil ranges of the Ravin du Bès Section. The semiquantitative distribution of nannofloras was coded as follows: Total abundance. C = 10–15 specimens in each field of view; FC = few/common: 5–9 specimens in each field of view; F = few: about 5 specimens in each field of view; RF=rare/few: 2–5 specimens in each field of view; R = rare: 1 specimen in each field of view. Preservation. M = moderate: little evidence of dissolution and/or overgrowth is present; primary morphological characteristics are sometimes altered; MP = moderate/poor: evidence of dissolution and/or overgrowth is present; primary morphological characteristics are sometimes modified, fragmentation has occurred; P = poor: most specimens exhibit dissolution or overgrowth; primary morphological characteristics are sometimes destroyed; fragmentation has occurred. Species abundance. A = abundant: >10 specimens in each field of view; C = common: 1 specimen in 1–9 fields of view; FC = few/common: 1 specimen every 10 fields of view; F = few: 1 specimen in 11–29 fields of view; RF = rare/few: 1 specimen every 30 fields of view; R = rare: 1 specimen in 31–100 fields of view.

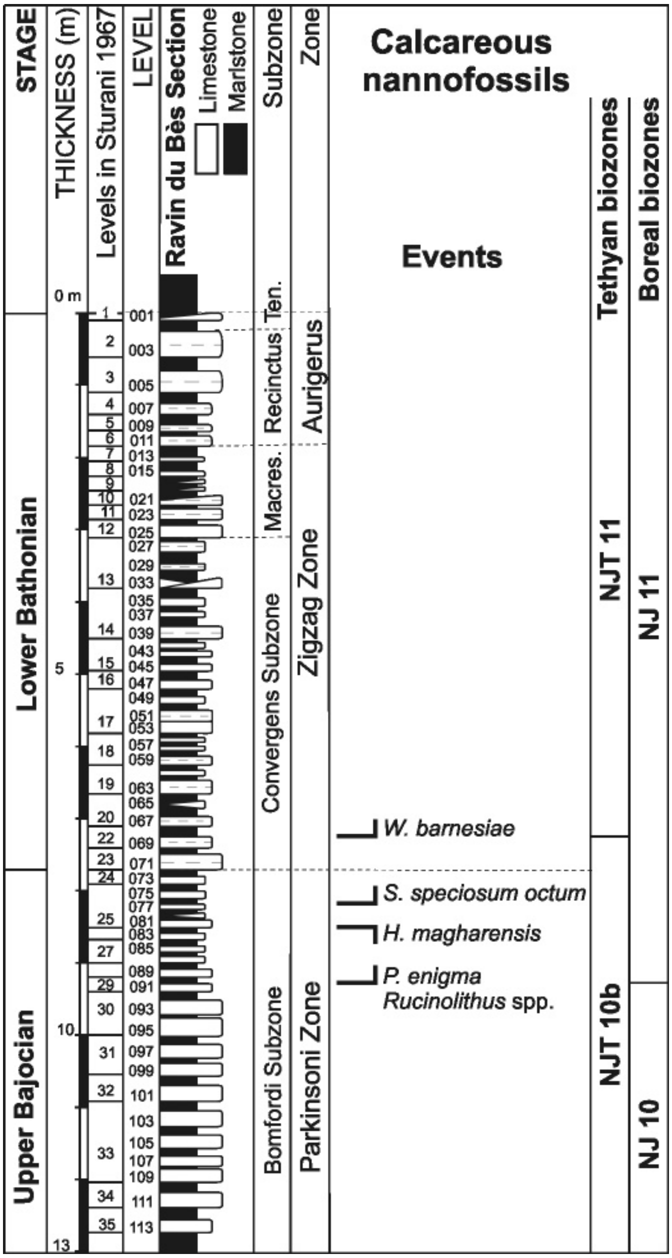

Fig. 10. Nannofossil events detected in the Ravin du Bès Section. Tethyan biozones after Mattioli & Erba (1999) and Boreal biozones after Bown & Cooper (1998).

turnover of the ammonoid succession across the boundary in Bas Auran area or the low faunal turnover at the Bajocian/Bathonian transition, but the strong provincialism with three separate realms.

Figure 12 shows standard zonations for the three ammonite biogeographical provinces represented in western Europe. Ammonites of the Zigzag Zone have a wide distribution through the Northwest European, Sub-Mediterranean and Mediterranean provinces of the West Tethyan Subrealm. In the Bas-Auran area, where Northwest European and Sub-Mediterranean taxa are relatively common, the primary standard Convergens Subzone and the secondary standard Parvum Subzone can be recognized.

The Northwest European Province, in which parkinsonids are common, comprises the following epeiric areas: England (Torrens 1980; Callomon 1995, 2003; Callomon & Cope 1995; Page 1996b, 2001; Dietze and Chandler 1998; Chandler et al. 1999), Normandy, Boulonnais, Lorraine, Alsace, northern Jura (Mangold & Rioult 1997, Rioult et al. 1997, Thierry 2003), northern Germany (Westermann 1958; Metz 1990, 1992), northern and central Poland (Kopik 2006; Zaton 2006).

The Sub-Mediterranean Province, in which Bathonian *Morphoceras* [M] – *Ebrayiceras* [m] occur associated with parkinsoniids and scarce phylloceratids and lytoceratids, includes the following epeiric areas: Lusitanian Basin (Fernández-López et al. 2006a, b), Iberian Basin (Fernández-López 2000, 2001), Aquitaine, Causses, Centre-west France, Nièvre (Delance et al. 1979; Courville et al. 1999; Enay et al. 2001), Mâconnais, Ardèche, southern Jura (Elmi 1967; Mangold 1971a, b, c, 1997a, b; Rulleau 2006), western Alps and Subalpine Basin (Sturani 1967; Pavia & Sturani 1968; Pavia 1973, 1984; Torrens 1987; Innocenti et al. 1990; Zany et al. 1990; Joly 2000), southern Germany (Dietl 1978, 1981, 1982, 1983, 1986, 1988; Dietl et al. 1978, 1983; Dietl & Hugger 1979; Dietl & Kapitzke 1983; Callomon et al. 1987; Schairer 1987, 1994; Dietze & Chandler 1996; Köstler & Schairer 1996; Dietze et al. 1997, 2002, 2004, 2007; Schweigert & Dietze 1998; Dietze 2000; Dietze & Schweigert 2000; Schweigert et al. 2002, 2003, 2007; Ohmert et al. 2004; Dietze & Dietl 2006), South Poland (Luczynski et al. 2000; Matyja & Wierzbowski 2000, 2001; Zaton & Marynowski 2006), Pieniny Klippen Belt (Wierzbowski et al. 1999; Schlögl & Rakús 2004; Schlögl et al. 2005, 2006), South Transdanubian Mecksek (Galácz 1995a; Geczy & Galácz 1998), Romania (Galácz 1994; Patrulius 1996), Balkans (Stephanov 1972), northwestern-central Iran (Seyed-Emami et al. 1985, 1989, 1991, 1998a, b) and north-eastern Iran (Majidifard 2003).

The Mediterranean Province, in which Late Bajocian and Early Bathonian morphoceratids occur associated with common phylloceratids and lytoceratids, comprises the following shelfal or oceanic areas: Betic Basin (Mangold 1981; Sandoval 1983, 1986, 1990; Sandoval et al. 2001), Majorca (Sandoval 1994), Sicily (Wendt 1963, 1971; Galácz 1985, 1999a, b; Pavia & Cresta 2002; Pavia et al. 2002; Martire & Pavia 2004; Pavia 2007), Alps (Sturani 1971; Krystyn 1972; Joly 2000; Martire 1989; Mangold & Gygi 1997) and North Transdanubian Hungary (Galácz 1980, 1993, 1995b).

In the north-eastern Tethyan border (Donetz, Crimea, Caucasus, Great Balkan, Turkmenistan, Tadzhikistan, Uzbekistan, Kazakhstan) latest Bajocian to Early Bathonian parkinsonids and morphoceratids have been described, below Middle Bathonian specimens of *Bullatimorphites*, *Procerites* and *Siemiradzkia* (Rostovtsev 1985; Tseretely 1989; Beznosov & Mitta 1998, 2000).

In Tibet and South-East Asia, Bathonian *Siemiradzkia, Procerites* and *Wagnericeras* have been identified (Cariou & Enay

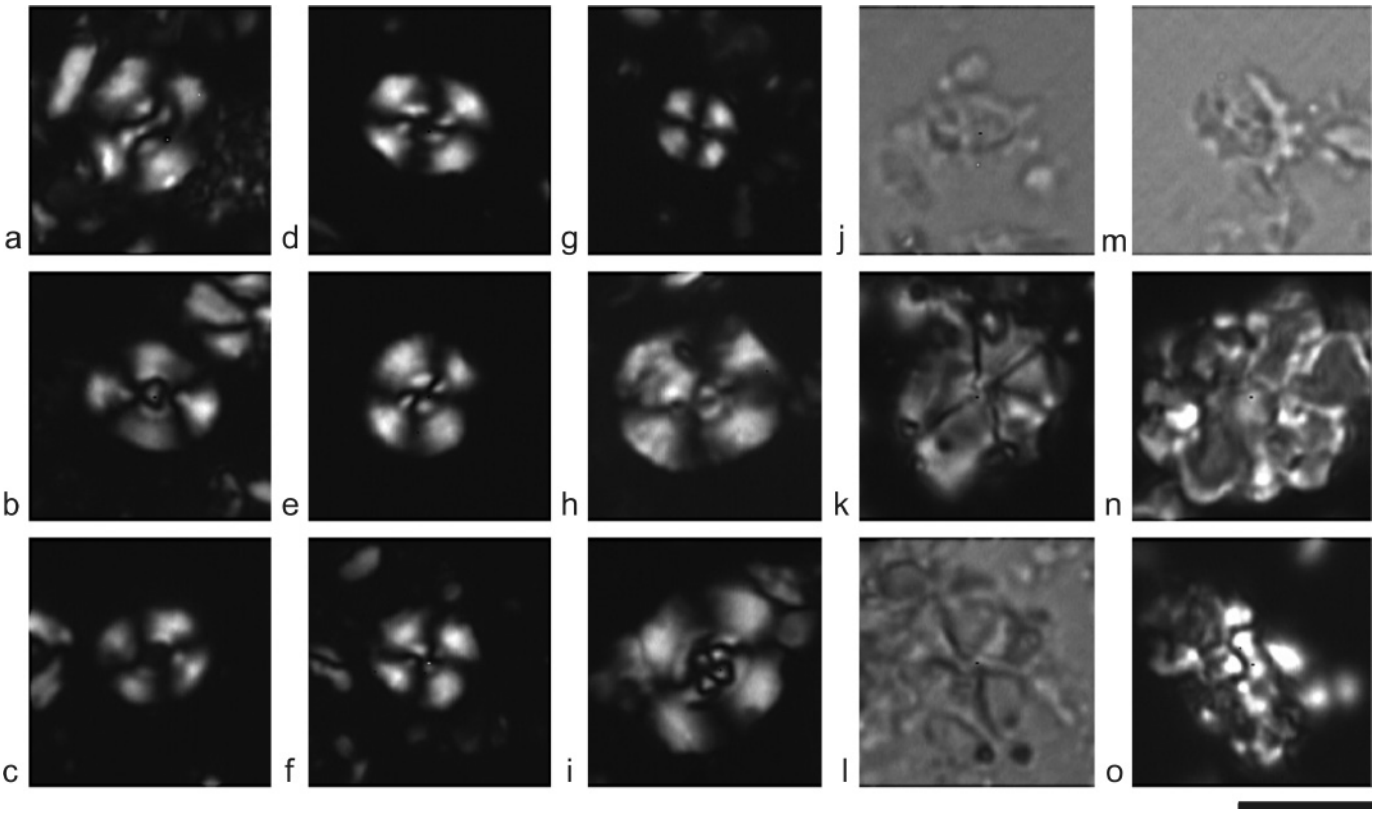

Fig. 11. Upper Bajocian and Lower Bathonian calcareous nannofossils from the Bas-Auran area. All specimens at 1250x magnification. (a): *Watznaueria communis*, crossed nicols, sample 110. (b): *Watznaueria britannica*, crossed nicols, sample 102. (c): *Watznaueria fossacincta*, crossed nicols, sample 110. (d): *Watznaueria* aff. *W. barnesiae*, crossed nicols, sample 60. (e): *Watznaueria barnesiae*, crossed nicols, sample 68a. (f): *Watznaueria barnesiae*, crossed nicols, sample 10. (g): *Cyclagelosphaera margerelii*, crossed nicols, sample 40. (h): *Watznaueria manivitiae*, crossed nicols, sample 67. (i): *Watznaueria* aff. *W. contracta*, crossed nicols, sample 48. (j): *Stephanolithion speciosum octum*, transmitted light, sample 76. (k): *Hexalithus magharensis*, crossed nicols, sample 110. (l): *Hexalithus magharensis*, transmitted light, sample 110. (m): *Stephanolithion speciosum speciosum*, transmitted light, sample 76. (n): *Rucinolithus* sp., crossed nicols, sample 6. (o): *Pseudoconus enigma*, crossed nicols, sample 53. Scale bar is 5 µm.

	NW European Province		**Sub-Mediterranean Province**		**Mediterranean Province**	
	England, Normandy, Boulonnais, Lorraine, Alsace, northern Germany, northern and central Poland.		Portugal, Iberian Basin, Aquitaine, Causses, Centre-west France, Nièvre, southern Jura, Mâconnais, Ardèche, southern Germany southern Poland, Balkans, northern and central Iran.		Betic Basin, Sicily, Appennines, Switzerland, Austria, Hungary p.p. (Villany and Mecsek), Hellenids, Serbia.	
Lower Bathonian	Tenuiplicatus		Aurigerus	Tenuiplicatus	Aurigerus	Postpollubrum
Lower Bathonian	Zigzag	Yeovilensis	Aurigerus	Recinctus	Aurigerus	Yeovilensis
Lower Bathonian	Zigzag	Macrescens	Zigzag	Macrescens	Zigzag	Macrescens
Lower Bathonian	Zigzag	Convergens	Zigzag	Parvum	Zigzag	Dimorphitiformis
Upper Bajocian	Parkinsoni	Bomfordi	Parkinsoni	Bomfordi	Parkinsoni	Dimorphus
Upper Bajocian	Parkinsoni	Truellei	Parkinsoni	Densicosta	Parkinsoni	Daubenyi
Upper Bajocian	Parkinsoni	Acris	Parkinsoni	Acris	Parkinsoni	

Fig. 12. Ammonite zones and subzones of the Uppermost Bajocian and Lower Bathonian in several palaeobiogeographical provinces: Northwest European (Westermann & Callomon 1988; Callomon & Cope 1995; Callomon 2003), Sub-Mediterranean (Mangold 1990; Rioult et al. 1997; Mangold & Rioult 1997) and Mediterranean (Galácz 1980, 1993; Sandoval 1983, 1990; Sandoval et al. 2001; O'Dogherty et al. 2006) provinces.

1999; Yin et al. 2000; Yin 2005). Upper Bajocian *Leptosphinctes* and *Cadomites* have been recognized in Japan, below Upper Bathonian *Pseudoneuqueniceras* (Sato 1992).

Lower Bathonian morphoceratids, parkinsoniids and phylloceratids have been recognized in several basins of the southern Tethyan border: Morocco, Algeria and Tunisia (Elmi 1971; Elmi & Alméras 1984; Enay et al. 1987b; Ouahhabi 1994; Soussi et al. 2000). *Oraniceras*, *Micromphalites* and *Oxycerites* occur in Lower Bathonian, whereas *Ermoceras*, *Leptosphinctes* and *Oppelia* characterize Upper Bajocian deposits.

In the Ethiopian Province, including Libya, Egypt, Israel, southern Turkey, southern Iran and Saudi Arabia (Parnes 1981, 1984, 1988; Enay et al. 1986, 1987a; Enay & Mangold 1994, 1996), the Lower Bathonian comprises the Tuwaiqensis (*Tulites*) and Clydocromphalus (*Micromphalites*) zones of the Arabian Province, including *Procerites* and *Zigzagiceras* in basal levels. Upper Bajocian deposits with *Ermoceras*, *Thambites*, *Leptosphinctes* and *Spiroceras* represent the Runcinatum (*Ermoceras*), Mogharense (*Ermoceras*) and Planus (*Thambites*) zones.

In the Indo-Malgach Province, Late Bajocian and Middle Bathonian ammonites, but not Early Bathonian, have been described from Kenya, Madagascar and India (Singh et al. 1982, 1983; Jaitly & Singh 1983, 1984; Pandey & Agrawal 1984; Pandey & Westermann 1988; Galácz 1990; Pandey & Callomon 1995; Prasad et al. 2007; Roy et al. 2007).

In south-western Pacific areas, Sula, Irian Jaya and New Guinea, latest Bajocian to Early Bathonian *Pretulites* and Early to Middle Bathonian *Satoceras*, as well as Bathonian specimens of *Asphinctites*, *Rugiferites* and *Bullatimorphites* have been described (Westermann & Getty 1970; Westermann & Callomon 1988; Sukamto & Westermann 1992; Westermann 1995, Callomon & Rose 2000).

Separate Late Bajocian and Early Bathonian ammonoid faunas have been distinguished, associated with characteristic Eurycephalitinae, in the southern East-Pacific Subrealm of the Tethyan Realm: New Zealand (Westermann & Hudson 1991; Westermann 1993b; Westermann et al. 2000, 2002), Argentina, Chile and Peru (Westermann & Riccardi 1980; Westermann et al. 1980; Riccardi 1985, 1991; Riccardi et al. 1990a, b, 1991, 1992, 1994; Riccardi & Westermann 1991a, b, 1999; Hillebrandt et al. 1992a, b; Fernández-López et al. 1994; Gröschke & Hillebrandt 1994; Hillebrandt 1995, 2001; Gröschke 1996; Parent 1998). *Leptosphinctes*, *Lupherites, Strenoceras, Spiroceras* and *Megasphaeroceras* occur in the Upper Bajocian of the Andean Province. *Lobosphinctes intersertus* Buckman has been identified in Chacay Melehue (Argentina) below a Bathonian *Cadomites*-Tulitidae mixed assemblage. The first occurrence of several genera such as *Oxycerites*, *Zeissoceras*, *Prohecticoceras and Rugiferites*, below the oldest representatives of Bathonian *Bullatimorphites*, have been used to recognize Lower Bathonian deposits. New species of Bathonian ?*Zigzagiceras* and *Morphoceras* have been proposed (Gröschke & Hillebrandt 1994; Riccardi & Westermann 1999).

In Mexico (Sandoval & Westermann 1986; Sandoval et al. 1990) Upper Bajocian begins with the upper Floresi Zone of Oaxaca, containing the Mediterranean *Subcollina lucretia* (Orbigny). The overlaying Zapotecum Zone includes *Parastrenoceras*, *Leptosphinctes* and *Oppelia*. The Upper Bathonian Retrocostatum Zone has been identified by *Prohecticoceras blanazense*, associated with *Epistrenoceras*, *Lilloettia* and *Neuqueniceras*.

In the Western Interior of the United States of America (Shoshonean Province, Imlay 1981), western Canada and southern Alaska (Athabascan Province; Imlay 1980, 1982, 1984; Hall & Westermann 1980; Hall & Stronach 1981; Callomon 1984; Hall 1984, 1988, 1989; Poulton et al. 1991, 1994) the Upper Bajocian Rotundum Zone includes *Leptosphinctes*, *Lupherites, Spiroceras* and *Megasphaeroceras*, below the *Epizigzagiceras-Parareineckeia* association. The *Parachondroceras-Sohlites* assemblages from Oregon may be Upper Bajocian or Lower Bathonian (Imlay 1984).

The Boreal Realm (Eastern Greenland, Siberia, Northern Alaska and Northern Canada) became clearly differentiated in the Late Bajocian and several zonations for the Early Bathonian have been proposed. The Cardioceratidae, in particular *Cranocephalites* and *Arctocephalites*, constituted characteristic elements of the Boreal Realm at the Bajocian/Bathonian boundary (Callomon 1985). The Zone of *Arctocephalites arcticus* (Newton & Teall), above the Zone of *Cranocephalites pompeckji* (Madsen), may represent the basal Bathonian zone in the Boreal Realm (Callomon 1993, 1994, 2003; Rawson 1982; Zakharov et al. 1998). The Zone of *Arctocephalites spathi* from northern Yukon probably is coeval with the Boreal Articus Zone of eastern Greenland (Poulton 1987). Boreal Arctocephalitinae are associated with parkinsoniids in the south-eastern part of the Russian platform, allowing the correlation between the regional Michalskii-Besnosovi zonal boundary and the Boreal Arcticus-Greenlandicus boundary or the Northwest European Parkinsoni-Zigzag boundary (Mitta 2001, 2004, 2005, 2006, 2007; Mitta & Seltzer 2002; Mitta et al. 2004; Saltykov 2007; Zakharov 2007).

Other taxonomic groups

Several authors have proposed diverse biozonations for the Upper Bajocian and Lower Bathonian based in different taxonomic groups of macroinvertebrates: brachiopods (Manceñido & Dagys 1992; Vörös 2001; Alméras et al. 2007), belemnites (Challinor 1992; Challinor et al. 1992; Combémorel 1997), nautiloids (Branger 2004), bivalves (Damborenea et al. 1992; Hallam 1994; Damborenea 2002; Ruban 2006), echinoderms (Thierry et al. 1997; Moyne et al. 2005), corals (Beauvais 1992).

The following taxonomic groups of microfossils are of biochronostratigraphic relevance also: foraminifera (Bassoullet 1997; Ruget & Nicollin 1997; Gräfe 2005; Cai et al. 2006; Saltykov 2007; Wernli & Görög 2007), ostracods (Braun & Brooke 1992; Bodergat 1997), dinoflagellate cysts (Riding & Thomas 1992; Fauconnier 1997; Poulsen & Riding 2003), radiolarians and calcareous nannofossils (Pessagno & Mizutani, 1992; Baumgartner et al. 1995; Cordey et al. 2005; Chiari et al. 2007). Palaeobotanical and palynological data have been recently published by: Kimura et al. 1992; Sarjeant et al. 1992; Cleal & Rees 2003; Wang et al. 2005; Vaez-Javadi & Mirzaei-Ataabadi 2006; Jana & Hilton 2007.

Isotope stratigraphy

From a geochemical point of view, in the French Subalpine Basin during the Jurassic Period, several authors have emphasized that the manganese content of pelagic carbonates is related to 2nd-order sea-level changes and episodes of hydrothermal activity that affected the chemistry of global sea water. The main transgressive phases are marked by a manganese content increase, whereas regressive phases are characterized by decreasing trends (Corbin 1994; Corbin et al. 2000). In the Chaudon-Norante section, 4 km north of the Bas-Auran area, the Early Bathonian maximum transgressive is marked by sedimentary condensations, associated with high manganese content (from 300 to 1370 mg kg^{-1}). In contrast, the Middle and

Late Bathonian regressive phase coincides with low manganese content periods. These stratigraphical patterns in divalent manganese can be of either local or regional significance, being concentrated, most probably as a very early diagenetic phase, only in oxygen-depleted waters that typically underlie zones of elevated organic productivity (Jenkyns et al. 2002). For strontium isotope ($^{87}Sr/^{86}Sr$ ratio), oxygen isotope ($\delta^{18}O$) or carbon isotope ($\delta^{13}C$) chemostratigraphy, no data are currently available.

Volcanogenic deposits suitable for direct radio-isotope dating are not known in the section. The age of the Bajocian/Bathonian boundary has been dated 167.7 ± 3.5 Ma by Gradstein & Ogg (2004) and Gradstein et al. (2005).

Magnetostratigraphy (R. Lanza)

In the autumn 1994, the Bas-Auran section was extensively sampled across the Bajocian/Bathonian boundary. Some 30 hand-samples were collected and cored in the rock-magnetism laboratory of Torino University. All specimens were measured with a JR-5 spinner magnetometer and thermally demagnetized using a Schonstedt furnace (Degiorgis 1996).

The specimens are characterized by three remanent magnetization components: (1) a viscous (VRM) component close to the present field and removed at temperature values about 120 °C; (2) a secondary component stable up to values of 300 to 450 °C; and (3) a high-temperature component, stable between 350–450 and 480–500 °C.

The secondary component has been interpreted as a Tertiary magnetic overprint: declination points to the NW (310° to 330°), inclination is positive (30° to 50°).

The high-temperature component has been isolated only in 11 out of the 32 analyzed specimens. Its definition is difficult and often poor, because its intensity is very low, usually 10–25% of the initial NRM. This component may be regarded as the more stable fraction of the primary Jurassic remanence acquired when the rocks formed. The fact that the primary remanence can be isolated only in few specimens and its poor definition prevent any reliable magnetostratigraphic interpretation.

The results found by Degiorgis (1996) in the Bas-Auran section have been fully substantiated in the whole southern Subalpine Chains by Aubourg & Chabert-Pelline (1999).

Gamma-ray spectrometry

Field gamma-ray spectrometry data have been obtained by G. Pavia, P. Lazarin and L. Leroy (April 2007) and are shown in Figure 13. Spectral gamma-ray data from the Ravin du Bès Section show an increase in the total gamma-ray counts at the Aurigerus Zone. The values are relatively low and display insignificant variation at the Bajocian-Bathonian boundary, but they show a positive peak at the top of the Lower Bathonian. Total gamma-ray logs have been used in sequence stratigraphy on the basis that gamma-ray peaks commonly correspond to maximum flooding surfaces (cf. Parkinson 1996; Deconinck et al. 2003; Pawellek & Aigner 2003, 2004; Pellenard et al. 2003; Raddadi et al. 2005; Ruf et al. 2005; Schnyder et al. 2006). High gamma-ray counts, low sedimentation rates and high concentrations of ammonites may be associated with the development of condensed sections in carbonate environments. These features, however, developed both in condensed deposits of deep carbonate environments during transgressions or episodes of relative sea-level rise and in expanded deposits of shallow carbonate epicontinental platforms during regressions or episodes of relative sea-level fall (Fernández-López et al. 2002). The stratigraphic trend in spectral gamma-ray data associated with sedimentary condensation on the Bas-Auran area, from the

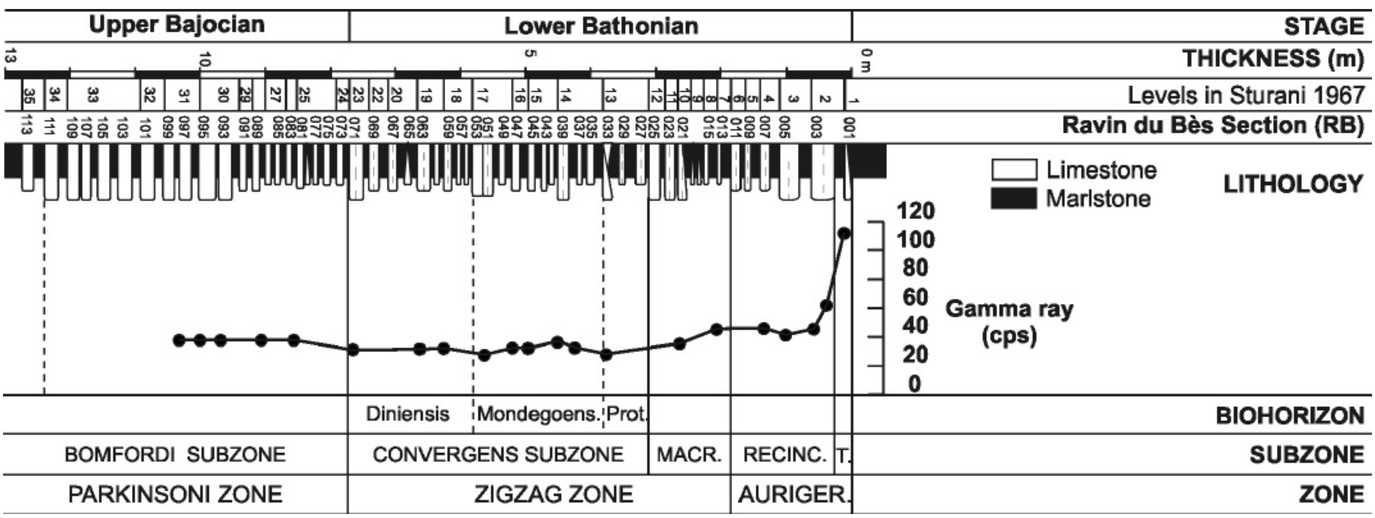

Fig. 13. Gamma-ray log of the Ravin du Bès Section showing a positive peak at the top of the "Marno-calcaires à *Cancellophycus*" in the Lower Bathonian Tenuiplicatus Subzone (Aurigerus Zone).

Bajocian Bomfordi Subzone towards Bathonian Tenuiplicatus Subzone, provides support for an Early Bathonian deepening half-cycle of 2nd order, lacking evidence of stratigraphic gaps at the Bajocian-Bathonian transition.

Therefore, the current data do not support the existence of a gap of the order of a whole biohorizon or even a subzone. The base of the bed RB071 is a minor sedimentary and stratigraphic discontinuity (tested with sequence stratigraphy and sedimentological data, as well as with palaeoichnological and taphonomic analyses), lacking evidence of significant hiatus (such as a peak in the spectral gamma-ray data shown in Fig. 13), non-existing evidence of biostratigraphic gap (as argued with diverse criteria in the chapter of record quality by Pavia et al. 2008) or missig biochronostratigraphic unit (the first subzone at the base of the Zigzag Zone, with three successive biohorizons, shows the highest biochronostratigraphic completeness, so far only recognized in the Cabo Mondego and Bas Auran sections, Fernández-López et al. 2007a).

Site protection (M. Guiomar)

The sites of Bas-Auran and Le Bès are part of the protected territory of "La Réserve Naturelle Géologique de Haute Provence". The Geological Reserve covering 55 communes in the departments "Alpes de Haute-Provence" and "Var" has been entrusted with the main missions of protecting, enhancing and raising awareness of the environment and supporting economic development of this heritage. These different missions are based on scientific knowledge of geological sites and inventories. This is why the Reserve wishes to encourage the number of scientific studies within its territory. While some of this research is instigated and supported by the Reserve itself and conducted in collaboration with its partners, academic or others, there is also independent research, conducted with technical support from the Reserve, in particular for the authorization to collect fossils. Two types of regulations apply in the protected territory: those relative to sites listed as natural reserves (Réserve Naturelle) by ministerial decree and those relative to protected areas, by prefectoral order (arrêtés préfectoraux). This explains why the sites of Bas-Auran and Le Bès do not have the same status. Bas-Auran is listed as a natural reserve (RN): no collecting or surface removal is possible, except by ministerial authorization. The section of Le Bès is part of the protected area where fossils may be collected and authorizations delivered for extraction or excavation (files managed by the Reserve), mainly in the context of research projects. Authorizations delivered by the Reserve in no way affect private property rights and all applications for excavation must be accompanied by a request to the owner of the land. According to the site's scientific value, the Reserve may request that a geological site be added to or removed from listing to facilitate its management and/or protection; exceptionally, the Reserve may approach local communities for the acquisition of certain lands. For the section(s) to obtain GSSP status, it is necessary to undertake all the requisite measures to maintain free access to them as well as consider minimum developments (ease of access, safety) as well as enhancement (to be defined with scientists and managers), whenever possible.

The Bajocian/Bathonian auxiliary stratotype in Cabo Mondego Section, Portugal (S.R. Fernández-López, M.H. Henriques & C. Mangold)

An auxiliary section and point (hereafter ASSP) for the base of the Bathonian Stage is located in Cabo Mondego, 40 km west of Coimbra, 7 km north of Figueira da Foz (40º 11' 19" N, 8º 54' 30" W, Section 02). It provides complementary data about the ammonite succession and biochronostratigraphic subdivision of the Sub-Mediterranean Parvum Subzone and the Northwest European Convergens Subzone.

These classical fossiliferous deposits have been studied by numerous specialists (Ruget-Perrot 1961; Elmi et al. 1971; Mangold 1971c, 1990; Rocha et al. 1981, 1987; Mangold & Rioult 1997; Fernández-López & Henriques 2002; Fernández-López et al. 2006a, b). The Bathonian deposits correspond to the Cabo Mondego Formation and comprise limestone-marl alternations, with ammonoids, bivalves (*Bositra*), rhynchonellid brachiopods, crinoids and belemnites. Bioturbation is common (*Zoophycos*, *Thalassinoides*, *Chondrites*). These fossiliferous deposits were developed in an open sea, in hemipelagic environments of distal and outer carbonate ramp, below the fair weather wave base (Watkinson 1989; Soares et al. 1993; Azerêdo et al. 2003).

In the Lusitanian Basin, Upper Bajocian and Lower Bathonian Phylloceratina and Lytoceratina account for less than 1% of the total ammonoid assemblage, and parkinsonids are very scarce (less than 5.0%). Successive ammonoid fossil assemblages are composed of Submediterranean taxa, but they allow correlation with the zonal scales of the diverse basins of the Mediterranean and NW European provinces.

The base of the Bathonian has been established by the lowest occurrence of representatives of the *Morphoceras* [M] – *Ebrayiceras* [m] group, at the base of the marly interval 123 of Section-02 (Fig. 14), which corresponds to the base of the marly interval FC1 of Section-90. The Lower Bathonian index ammonite *Morphoceras parvum* occurs in the marly interval 02CM139. The Lower Bathonian index ammonite *Gonolkites convergens* occurs in the marly interval 02CM181. From a biochronostratigraphic point of view, 10 metres of thickness with 62 successive ammonoid fossil-assemblages from 77 successive fossiliferous stratigraphic intervals have been recognized and sampled in the Parvum Subzone.

New taxa of Perisphinctidae, based on data from Cabo Mondego, are of primary relevance for the biochronostratigraphic subdivision and correlation of the Submediterranean Parvum Subzone. The lowest occurrences of *Bigotites mondegoensis* and *Protozigzagiceras* correspond to two successive biostratigraphic events allowing distinction of three successive biohorizons in the Parvum Subzone in Cabo Mondego (Lusitanian Basin) and Bas Auran (Alpine Basin): the Diniensis, Mondegoensis and Protozigzagiceras biohorizons

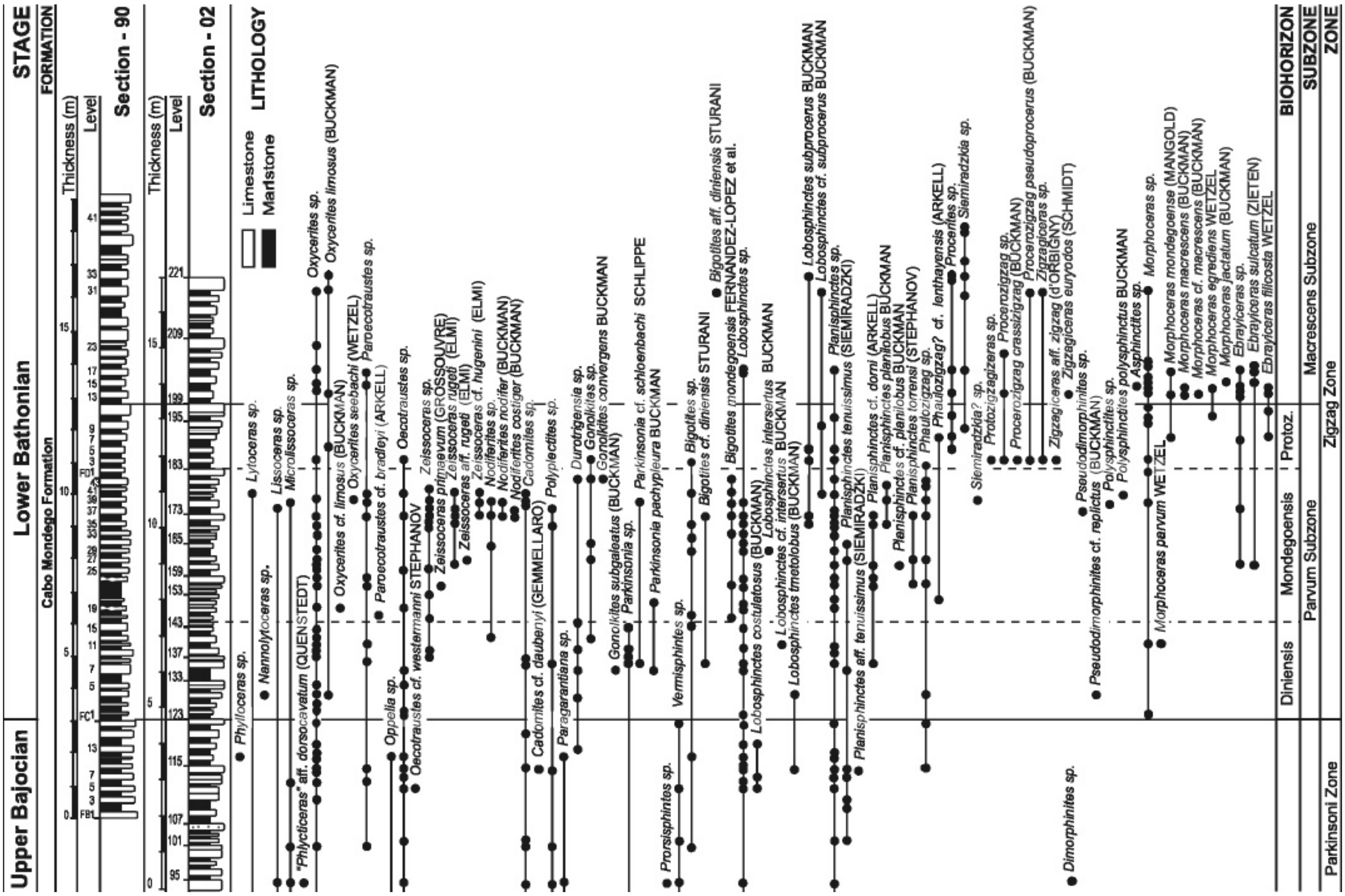

Fig. 14. Ammonite biochronostratigraphic data at the Bajocian/Bathonian boundary in the Section-90 and Section-02 of Cabo Mondego (Portugal, based on Fernández-López et al. 2006a, b).

(Fernández-López et al. 2007a; Pavia et al. 2008). The Diniensis Biohorizon is represented by the stratigraphic intervals 02CM123–02CM145 in Section 02 and FC1–FC17 in Section 90 (Fig. 14). The Mondegoensis Biohorizon is represented by the stratigraphic intervals 02CM146–02CM182 (Section 02) and FC18–FC43 (Section 90), taking into account the occurrence of *B. mondegoensis* at the level 02CM146. The Protozigzagiceras Biohorizon is represented by the stratigraphic intervals 02CM183–02CM198 (Section 02) and FC44–FD11 (Section 90), taking into account the occurrence of *Protozigzagiceras* at the level 04CM183.

New provisions for the conservation and protection of this Portuguese outcrop have now been implemented under national laws, after the classification of the Cabo Mondego area as a Natural Monument of the Portuguese Republic in 2007 (Henriques & Ramalho 2005; Page et al. 2006).

Summary

The leading candidate Global Boundary Stratotype Section and Point for the base of the Bathonian Stage at the Ravin du Bès Section (France) satisfies most of the requirements recommended by the ICS (e.g., Remane et al. 1996; Gradstein et al. 2003; Morton 2006):

The exposure extends over 13 m in thickness, comprising five metres of fossiliferous levels below the boundary and eight metres above. The stratigraphic succession can be recognized laterally over several hundred metres distance.

At the Bajocian-Bathonian transition, no vertical (bio-, ichno- or tapho-) facies changes, stratigraphic gaps or hiatuses have been recorded. There is no evidence of taphonomic condensation (i.e., mixture of fossils of different age or different chronostratigraphic units). In relation to the rate of sedimentation, the Bomfordi and Convergens subzones are over 10 m thick.

Structural complexity, synsedimentary and tectonic disturbances, or important alterations by metamorphism are not relevant constraints in the Bas-Auran area.

The hemipelagic, bed-scale limestone-marl alternations show a maximum value of biostratigraphic completeness for the Bajocian/Bathonian transition. The Northwest European primary standard Convergens Subzone and the Sub-Mediterranean secondary standard Parvum subzones are in fact precisely coeval in the Bas-Auran area. Through five metres of thickness, 46 successive ammonoid fossil-assemblages in Ravin du Bès Section belonging to three biohorizons of the Parvum Subzone have been recognized. The Bomfordi Subzone attains a minimum thickness of 5 m and includes 42 successive ammonoid fossil-assemblages.

The boundary has been characterized by both primary and secondary (auxiliary) biostratigraphic markers. There is a well-preserved, abundant and diverse fossil record across the boundary interval, with key markers (ammonites and nannofossils) for worldwide correlation of the uppermost Bajocian and Lower Bathonian. The section appears to be suitable for biostratigraphic study of microfossils, such as foraminifera, but as yet there are no published studies.

Regional analyses of sequence stratigraphy and manganese chemostratigraphy are available. A transgressive systems tract associated with a deepening phase and sedimentary starvation, within 3rd and 2nd order deepening/shallowing cycles, was developed in the Bas-Auran area of the French Subalpine Basin, during the Early Bathonian. No data are currently available for strontium isotope ($^{87}Sr/^{86}Sr$ ratio), oxygen isotope ($\delta^{18}O$) or carbon isotope ($\delta^{13}C$) chemostratigraphy.

The stratigraphic trend in spectral gamma-ray data provides support for an Early Bathonian deepening half-cycle of second order.

Bajocian and Bathonian deposits have been remagnetized with a steady normal polarity. The requirement of suitability for magnetostratigraphy and geochronometry, however, can be indirectly satisfied by reference to the Bathonian magnetostratigraphic scale of Steiner et al. (1987; O'Dogherty et al. 2006) as defined in the Subbetic Cordillera.

Volcanogenic deposits suitable for direct radio-isotope dating are not known in the section. According to the data published by Gradstein & Ogg (2004) and Ogg (2004), the age of the Bajocian/Bathonian boundary is 167.7 ± 3.5 Ma in other basins.

The criteria of accessibility, conservation and protection are assured by the "Réserve Naturelle Géologique de Haute Provence", protected under national law and recognised by UNESCO. The park is managed by the "Centre de Géologie de Digne".

The Cabo Mondego Section is suggested as the Bathonian ASSP within the same GSSP proposal. It provides complementary data about the ammonite succession and biochronostratigraphic subdivision of the Sub-Mediterranean Parvum Subzone and the Northwest European Convergens Subzone, at the basal Bathonian Zigzag Zone. Accessibility, conservation and protection are guaranteed, after the classification of the Cabo Mondego area as a Natural Monument of the Portuguese Republic in 2007.

Acknowledgements

We would like to thank all members of the Bathonian Working Group and in particular J.H. Callomon, V. Dietze, V. Mitta, N. Morton, K. Page, D.K. Pandey, T.P. Poulton and A. Wierzbowski, for constructive comments which improve this paper. We are grateful to Felix M. Gradstein (Museum of Natural History, University of Oslo), an anonymous referee and the editor Daniel Marty for constructive suggestions of the manuscript. This work has been supported by the CGL2004-0694/BTE (MEC-CSIC) and CGL2008-01273/BTE (MICIIN) projects, and grants from the 2006 and 2007 Geoconservation Projects, respectively coordinated at the Madrid and Torino universities.

REFERENCES

Alméras, Y., Faure, P., Elmi S., Enay, R. & Mangold, C. 2007: Zonation des brachiopodes du Jurassique moyen sur la marge sud de la Téthys occidentale (Maroc, Algérie occidentale) Comparaison avec la marge nord-téthysienne française. Geobios 40, 1–19.

Arkell, W.J. 1951–1959: A monograph of English Bathonian ammonites. Palaeontographical Society, London, 264 pp.

Arkell, W.J. 1956: Jurassic geology of the world. Oliver & Boyd Ltd., London, 806 pp.

Aubourg, C. & Chabert-Pelline, C. 1999: Neogene remagnetization of normal polarity in the Late Jurassic black shales from the southern Subalpine Chains (French Alps). Evidence for late anticlock wise rotations. Tectonophysics 308, 473–486.

Azerêdo, A.C., Duarte, L.V., Henriques, M.H. & Manuppella, G. 2003: Da dinâmica continental no Triásico aos mares do Jurássico Inferior e Médio. Cadernos de Geologia de Portugal 2003, 1–43.

Bassoullet, J.-P. 1997: Les grandes foraminifères. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 293–304.

Baumgartner, O.P., O'Dogherty, L., Gorican, S. Urquhart, E., Pillevuit, A. & De Wever, P. 1995: Middle Jurassic to lower Cretaceous Radiolaria of Tethys: occurrences, systematics, Biochronology. Mémoires de Géologie 23, 1–1162.

Beauvais, L. 1992: Corals of the circum-Pacific region. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 324–327.

Beznosov, N.V. & Mitta, V.V. 1998: Catalogue of Ammonitida and key sections of the Upper Bajocian – Lower Bathonian of North Caucasus [in Russian]. VNIGNI, Nedra, Moscow, 72 pp.

Beznosov, N.V. & Mitta, V.V. 2000: Jurassic geology and ammonites of Great Balkhan (Western Turkmenistan) [in Russian]. VNIGNI, Nedra, Moscow, 115 pp.

Bodergat, A.-M. 1997: Les ostracodes marines du Jurassique européen. Utilisation stratigraphique. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 197–223.

Bown, P.R. & Cooper, M.K.E. 1998: Jurassic. In Bown, P.R. (Ed.): Calcareous Nannofossil Biostratigraphy. Kluwer Academic Publishers, London, 34–85.

Bown, P.R., Cooper, M.K.E. & Lord, A.R. 1988: A calcareous nannofossil biozonation scheme for the early to Mid Mesozoic. Newsletter on Stratigraphy 20, 91–114.

Branger, P. 2004: Middle Jurassic Nautiloidea from western France. Revista Italiana di Paleontologia e Stratigrafia 110, 141–149.

Braun, W.K. & Brooke, M.M. 1992: Ostracods of western Canada. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 296–299.

Buckman, S.S. 1909–1930: Yorkshire Type Ammonites and Type Ammonites. Wesley, London, 790 pls.

Cai, H.-W., Li, J.-G. & Zhang, B.-G. 2006: Early and Middle Jurassic foraminifera from Tingri and Nyalam regions of southern Tibet, China. Acta Palaeontologica Sinica 45 (4), 437–452.

Callomon, J.H. 1984: A review of the biostratigraphy of the post-Lower Bajocian Jurassic ammonites of western and northern North America. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 143–174.

Callomon, J.H. 1985: The evolution of the Jurassic ammonite family Cardioceratidae. Special Papers in Palaeontology 33, 49–90.

Callomon, J.H. 1993: The ammonite succession in the Middle Jurassic of East Greenland. Bulletin of the Geological Society of Denmark 40, 83–113.

Callomon, J.H. 1994: Jurassic ammonite biochronology of Greenland and the Artic. Bulletin of the Geological Society of Denmark 41, 128–137.

Callomon, J.H. 1995: Time from fossils: S.S. Buckman and Jurassic high-resolution geochronology. Geological Society, London, Memoirs 16, 127–150.
Callomon, J.H. 2003: The Middle Jurassic of western and northern Europe: its subdivisions, geochronology and correlations. Geological Survey of Denmark and Greenland Bulletin 1, 61–73.
Callomon, J.H. & Cope, J.C.W. 1995: The Jurassic Geology of Dorset. In: Taylor, P.D. (Ed.): Field Geology of the British Jurassic. Geological Society, London, 51–104.
Callomon, J.H. & Rose G. 2000: Middle Jurassic ammonites from the island of Babar in the southern Moluccan Forearc, Indonesia. Revue de Paléobiologie 8, 53–64.
Callomon, J.H., Dietl, G., Galácz, A., Grandl, H., Niederhöfer, H.J. & Zeiss, A. 1987: Zur Stratigraphie des Mittel- und unteren Oberjuras in Sengenthal bei Neumarkt/Opf. (Fränkische Alb). Stuttgarter Beiträge zur Naturkunde 132, 1–53.
Cariou, E. & Enay, R. 1999: Les ammonites du Bathonien et du Callovien de Thakkhola (Népal Central): biochronologie et intérêt paléobiogéographique. Geobios 32, 701–726.
Cariou, E., Contini, D., Dommergues, J.L., Enay, R., Geyssant, J.R., Mangold C. & Thierry J. 1985: Biogéographie des Ammonites et évolution structurale de la Téthys au cours du Jurassique. Bulletin de la Société géologique de France 1, 679–697.
Challinor, A.B. 1992: Belemnites of the southwest Pacific. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 308–310.
Challinor, A.B., Doyle, P., Howlett, P.J. & Nal'nyaeva, T.I. 1992: Belemnites of the circum-Pacific region. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 334–341.
Chandler, R.B., Glover, L. & Smith, D. 1999: A temporary section in the Inferior Oolite (Middle Jurassic) at Coldharbour Business Park, Dodge Cross, Sherborne. Proceedings of the Dorset Natural History and Archaeological Society 120 (1998), 69–72.
Chiari, M., Cobianchi, M. & Picotti, V. 2007: Integrated stratigraphy (radiolarians and calcareous nannofossils) of the Middle to Upper Jurassic Alpine radiolarites (Lombardian Basin, Italy): Constraints to their genetic interpretation. Palaeogeography, Palaeoclimatology, Palaeoecology 249, 233–270.
Cleal, C.J. & Rees, P.M. 2003: The Middle Jurassic flora from Stonesfield, Oxfordshire, UK. Palaeontology 46, 739–801.
Cobianchi, M., Erba, E. & Pirini Radrizzani, C. 1992: Evolutionary trends of calcareous nannofossil genera *Lotharingius* and *Watznaueria* during the Early and Middle Jurassic. Memorie Scienze Geologica 43, 19–25.
Combémorel, R. 1997: Bélemnites. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 157–167.
Corbin, J.C. 1994: Evolution géochimique du Jurassique du Sud-Est de la France: influence des variations du niveau marin et de la tectonique. Unpublished PhD Thesis, Paris VI University.
Corbin, J.C., Person, A., Iatzoura, A., Ferre, B. & Renard, M. 2000: Manganese in pelagic carbonates: indication of major tectonic events during the geodynamic evolution of a passive continental margin (the Jurassic European Margin of the Tethys–Ligurian Sea). Palaeogeography, Palaeoclimatology, Palaeoecology 156, 123–138.
Cordey, F., Boughdiri, M. & Sallouhi, H. 2005: First direct age determination from the Jurassic radiolarian-bearing siliceous series (Jédidi Formation) of northwestern Tunisia. Comptes Rendus Geosciences 337, 777–785.
Courville, P., Thierry, J. & Cariou, E. 1999: Modalités évolutives du genre *Bullatimorphites* (Ammonitina) au Bathonien-Callovien (Jurassique moyen) en Europe occidentale. Comptes Rendus de l'Académie des Sciences de Paris 323, 81–88.
Damborenea, S.E. 2002: Jurassic evolution of Southern Hemisphere marine palaeobiogeographic units based on benthonic bivalves. Geobios M.S. 24, 51–71.
Damborenea, S.E., Polubotko, I.V., Sey, I.I. & Paraketsov, K.V. 1992: Bivalves zones and assemblages of the circum-Pacific region. In: Westermann, E. G.E. (Ed): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 300–307.
Deconinck, J.F., Hesselbo, S.P., Debuisser, N., Averbuch, O., Baudin, F. & Bessa, J. 2003: Environmental controls on clay mineralogy of an Early Jurassic mudrock (Blue Lias Formation, southern England). International Journal of Earth Sciences 92, 255–266.
Degiorgis, C. 1996: Stratigrafia magnetica del Baiociano: la sezione di Puerto Escaño (Cordillera Subbetica, Spagna) e la sezione del Bas Auran (Alpes de Haute Provence, Francia). Unpublished Graduate Thesis, University of Torino, 109 pp.
Delance, J.H., Laurin, B. & Marchand, D. 1979: Observations sur la stratigraphie du Bathonien et du Callovien inférieur dans la région de Saint-Benin-d'Azy. Bulletin Scientifique de Bourgogne 32, 71–95.
Dietl, G. 1978: Die heteromorphen Ammoniten des Dogger (Stratigraphie, Taxonomie, Phylogenie, Ökologie). Stuttgarter Beiträge zur Naturkunde 33, 1–97.
Dietl, G. 1981: Zur systematischen Stellung von *Ammonites subfurcatus* Zieten und deren Bedeutung für die subfurcatum-Zone (Bajocium, Mittl. Jura). Stuttgarter Beiträge zur Naturkunde 81, 1–11.
Dietl, G. 1982: Das wirkliche Fundniveau von *Ammonites aspidoides Oppel* (Ammonoidea, Mittl. Jura) am locus typicus. Stuttgarter Beiträge zur Naturkunde 87, 1–21.
Dietl, G. 1983: Die Ammoniten-Gattung *Strenoceras* aus dem südwestdeutschen Subfurcaten-Oolith (Bajocium, Mittl. Jura). Stuttgarter Beiträge zur Naturkunde 90, 1–37.
Dietl, G. 1986: Erstnachweis von *Oecoptychius subrefractus* (S. Buckm.) (Ammonoidea) aus dem Unter-Bathonium (Mittl. Jura) von SW-Deutschland. Stuttgarter Beiträge zur Naturkunde 87, 1–21.
Dietl, G. 1988: Der Hamiten-Ton (Ober-Bajocium, Mittl. Jura) in Bauaufschlüssen der neuen Bundesauthobahn A8, Streckenabschnitt Aichelberg-Gruibingen. Jahreshefte der Gesellschaft für Naturkunde in Württemberg 143, 59–77.
Dietl, G. & Hugger, R. 1979: Zur Stratigraphie des Ober-Bajocium (Braunjura δ/ε-Grenzschichten) der Zollernalb (Schwäbische Alb, Baden-Württemberg). Stuttgarter Beiträge zur Naturkunde 43, 1–14.
Dietl, G. & Kapitzke, M. 1983: Das Bathonium (Mittlerer Jura) zwischen Aalen und Bopfingen, östl. Schwäb. Alb. 1. Mittel-Bathonium. Stuttgarter Beiträge zur Naturkunde 93, 1–27.
Dietl, G., Flaig, R. & Glück, E. 1978: Zur Stratigraphie der Ober-Bajocium (Braunjura δ/ε Grenzschichten) am Plettengerg bei Balingen, Württemberg. Stuttgarter Beiträge zur Naturkunde 40, 1–16.
Dietl, G., Hugger R. & Schaaf, D. 1983: Die Lage der Bajocium/Bathonium-Grenze (Mittlerer Jura) in der südwestlichen Schwäbischen Alb, SW-Deutschland. Jahreshefte der Gesellschaft für Naturkunde in Württemberg 138, 75–84.
Dietze, V. 2000: Feinstratigraphie und Ammonitenfauna der Acris-Subzone (Parkinsoni-Zone, Ober-Bajocium, Mittlerer Jura) am Ipf (östliche Schwäbische Alb, Süddeutschland). Stuttgarter Beiträge zur Naturkunde 295, 1–43.
Dietze, V. & Chandler, R.B. 1996: Die Zone des Zigzagiceras zigzag. Fossilien 1996/3, 159–166.
Dietze, V. & Chandler, R.B. 1998: New Ammonites from the Zigzag Bed of Dorset. Dorset Proceedings 119 (1997), 109–116.
Dietze V. & Dietl G. 2006: Feinstratigraphie und Ammoniten-Faunen-horizonte im Ober-Bajocium und Bathonium des Ipf-Gebietes (Schwäbische Alb, Südwestdeutschland). Stuttgarter Beiträge zur Naturkunde 360, 1–51.
Dietze, V. & Schweigert, G. 2000: Zur Stratigraphie und Ammonitenführung des Ober-Bajociums und Bathoniums, insbesondere der Zigzag-Zone, Convergens-Subzone, von Röttingen (östliche Schwäbische Alb, Südwestdeutschland). Stuttgarter Beiträge zur Naturkunde 284, 1–15.
Dietze, V., Krieger, T. &. Schweigert, G. 1997: Über *Oecoptychius subrefractus* (Buckman), *Asphinctites tenuiplicatus* (Brauns) und *Polysphinctites secundus* (Wetzel) (Ammonoidea) aus dem Unter-Bathonium (Mittlerer Jura) der Oberpfalz (Nordost-Bayern, Süddeutschland). Stuttgarter Beiträge zur Naturkunde 245, 1–25.
Dietze, V., Schweigert, G., Callomon, J.H. & Gauthier. H. 2002: Garantiana- und frühe Parkinsoni-Zone (Ober-Bajocium, Mittlerer Jura) am Ipf (östliche Schwäbische Alb, SW-Deutschland) mit Bemerkungen zur Phylogenie der Ammonitengattung *Garantiana* Mascke, 1907. Stuttgarter Beiträge zur Naturkunde 315, 1–89.

Dietze, V., Ermer, G., Görlich, M., Ivankic, Z., Krieger, Th. & Röper, M. 2004: Das Bajocium und Bathonium (Mittel-Jura) bei Greding (Fränkische Alb, Süddeutschland). Archaeopteryx 22, 61–74.

Dietze, V.; Schweigert, G.; Callomon, J.H.; Dietl, G. & Kapitzke, M. 2007: Der Mitteljura des Ipf-Gebiets (östliche Schwäbische Alb, Süddeutschland). Korrelation der süddeutschen Ammoniten-Faunenhorizonte vom Ober-Bajocium bis zum Unter-Callovium mit Südengland und Frankreich. Zitteliana, A47, 105–125.

Elmi, S. 1967: Le Lias supérieur et le Jurassique moyen de l'Ardèche. Documents des Laboratoires de Géologie Lyon 19, 509–845.

Elmi, S. 1971: Les faunes à *Prohecticoceras* (Oppeliidae, Ammonitina) du Bathonien inférieur et moyen des confins algéro-marocains. Geobios 4, 243–264.

Elmi, S. & Alméras, Y. 1984: Physiography, palaeotectonics and palaeoenvironments as controls of changes in ammonite and brachiopod communities (an example from the early and middle Jurassic of western Algeria). Palaeogeography, Palaeoclimatology, Palaeoecology 47, 347–360.

Elmi, S., Mangold, C., Mouterde, R. & Ruget, C. 1971: Révision de l'étage Bathonien au Cap Mondego (Portugal). Annales Instituti Geologici Publici Hungarici 54, 439–450.

Enay, R. & Cariou, E. 1999: Jurassic ammonite faunas from Nepal and their bearing on the palaeobiogeography of the Himalayan belt. Journal of Asian Earth Sciences 17, 829–848.

Enay, R. & Mangold, C. 1994: Première zonation par ammonites du Jurassique d'Arabie Saoudite, une référence pour la province arabique. Geobios 17, 161–174.

Enay, R. & Mangold, C. 1996: Dimorphisme dans le genre Ermoceras Douvillé, 1916 (Stephanoceratidae, Bajocien supérieur) et implication nomenclaturale. Comptes Rendus de l'Académie des Sciences de Paris 322, 791–798.

Enay, R., Le Nindre, C., Mangold, C., Manivit, J. & Vaslet, D. 1986: The Jurassic of Central Saudi Arabia: new data on lithostratigraphic units, paleoenvironments, ammonite fauna, ages and correlations. Technical Record, Bureau des Recherches Géologiques et Minières, 06–3, Deputy Ministry for mineral ressources, Jiddah, Kingdom of Saudi Arabia, 67 pp.

Enay, R., Le Nindre, C., Mangold, C., Manivit, J. & Vaslet, D. 1987a: Le Jurassique d'Arabie saoudite centrale: nouvelles données sur la lithostratigraphie, les paléoenvironnements, les faunes d'ammonites, les âges et les corrélations. Geobios 9, 13–65.

Enay, R., Mangold. C., Du Dresnay, R. & Rakus, M. 1987b: Arrivals of Arabian origin among the ammonite faunas of Morocco during the Bajocian-Bathonian. Palaeogeography, Palaeoclimatology, Palaeoecology 61, 107–120.

Enay, R., Gauthier, H., Trevisan, M., Berton, J.B., Brivet, L., Brodbeck, J. L., Demaizieres, J.F., Donie, P., Fourel, A. & Trehour, M. 2001: Les Micromphalites (Ammonitina) du Bathonien inférieur de la Nièvre (France): installation sur la marge européenne de la Téthys de formes sud-téthysiennes d'origine arabique et description d'un néotype de M. busqueti (de Gross.). Revue de Paléobiologie 20, 503–524.

Erba, E. 1990a: Calcareous nannofossils from the Bas Auran section. In: Rocha, R.B. & Soares, A.F. (Eds.): 2nd International Symposium on Jurassic Stratigraphy 1987 (1988). Centro de Estratigrafia e Paleobiologia, Univ. Nova de Lisboa, Lisbon, 343–345.

Erba, E. 1990b: Calcareous nannofossils biostratigraphy of some Bajocian sections from the Digne area (SE France). Memorie descrittive della Carta Geologica d'Italia 60, 237–256.

Fauconnier, D. 1997: Kystes de dinoflagellés des domaines nord-ouest européen et sud-téthysien. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 225–241.

Fernández-López, S. 2000: Lower Bathonian ammonites of Serra de la Creu (Tivissa, Catalan Basin, Spain). Revue de Paléobiologie 8, 45–52.

Fernández-López, S. 2001: Upper Bathonian ammonites of the Catalan Basin (Tivissa and Cap Salou, Spain). Hantkeniana 3, 25–39.

Fernández-López, S. R. 2003. Bathonian Working Group. International Subcommission on Jurassic Stratigraphy, Newsletter, 30, 15.

Fernández-López, S.R. 2007a: Bathonian Working Group. International Subcommission on Jurassic Stratigraphy. Newsletter, 34, 2, 13–14.

Fernández-López, S.R. 2007b: Ammonoid taphonomy, palaeoenvironments and sequence stratigraphy at the Bajocian/Bathonian boundary on the Bas Auran area (Subalpine Basin, SE France). Lethaia 40, 377–391.

Fernández-López, S.R. 2008: Candidate sections for GSSP of the base of Bathonian Stage (Middle Jurassic). Volumina Jurassica, in press.

Fernández-López, S.R. & Henriques, M.H. 2002: Upper Bajocian – Lower Bathonian ammonites of Cabo Mondego section (Portugal). In: Martire, L. (Ed.): 6th International Symposium on the Jurassic System, Abstracts and Programs. International Subcommision on Jurassic Stratigraphy, Mondello, 65–66.

Fernández-López, S., Chong Díaz, G., Quinzio Sinn, L.A. & Wilke, H.-G. 1994: The Upper Bajocian and Bathonian in the Cordillera de Domeyko, North-Chilean Precordillera: sedimentological and biostratigraphical results. Geobios 17, 187–201.

Fernández-López, S., Henriques, M.H.P. & Duarte, L.V. 2002: Taphonomy of ammonite condensed associations. Jurassic examples from carbonate platforms of Iberia. Abhandlungen der Geologischen Bundesanstalt 57, 423–430.

Fernández-López, S.R., Henriques, M.H. & Mangold, C. 2006a: Ammonite succession at the Bajocian/Bathonian boundary in the Cabo Mondego region (Portugal). Lethaia 39, 253–264.

Fernández-López, S.R., Henriques, M.H., Mangold, C. 2006b: Ammonite horizons at the basal Bathonian zone (Parvum Subzone) in Cabo Mondego, Portugal. Volumina Jurassica 4, 161.

Fernández-López, S.R., Henriques, M.H., Mangold, C. & Pavia, G. 2007a: New Early Bathonian Bigotitinae and Zigzagiceratinae (Ammonoidea, Middle Jurassic). Rivista Italiana di Paleontologia e Stratigrafia 113, 383–399.

Fernández-López, S.R., Pavia, G., Erba, E., Guiomar, M., Henriques, M.H., Lanza, R., Mangold, C., Olivero, D. & Tiraboschi, D. 2007b: Formal proposal for the Global Boundary Stratotype Section and Point (GSSP) of the Bathonian Stage, at the base of the Zigzag Zone in the Ravin du Bès Section (Bas-Auran, Subalpine Basin, SE France). International Subcommission on Jurassic Stratigraphy, Bathonian Working Group Ballot 2007, 43 pp.

Ferry, S. 1990: Post-field comments. Mesozoic eustacy record on western Tethyan margins. Post-meting field-trip in the Vocontian Trough. Publication of the Association des Sédimentologistes français 12, 121–140.

Galácz, A. 1980: Bajocian and Bathonian Ammonites of Gyenespuszta Bakony Mts., Hungary. Geologica Hungarica 39, 1–228.

Galácz, A. 1985: A Bathonian (Middle Jurassic) ammonite faunula from Monte Kumeta (Western Sicily). Fragmenta Mineralogica et Palaeontologica 12, 19–26.

Galácz, A. 1990: New collection of successive ammonite faunas from the Bajocian of Mombasa (Kenya, East Africa). Memoire Descrittive della Carta Geologica d'Italia 40, 199–204.

Galácz, A. 1993: Comparison of Hungarian Bathonian (Middle Jurassic) ammonite assemblages; suggestions on habitats. Discussiones Palaeontologicae 39, 25–33.

Galácz, A. 1994: The age of the ammonite fauna from the classic Middle Jurassic locality of Swinitza (Banat, Romania). Palaeopelagos S.P. 1, 167–179.

Galácz, A. 1995a: Ammonite stratigraphy of the Bathonian red limestone of the Mecsek Mts, south Hungary. Annales Universitatis Scientiarum Budapestinensis 30 (1994), 111–150.

Galácz, A. 1995b: Revision of the Middle Jurassic ammonite fauna from Csókahegy, Vértes Hills (Transdanubian Hungary). Hantkeniana 1, 119–129.

Galácz, A. 1999a: A Lower Bathonian ammonite fauna from Erice (Western Sicily). Annales Universitatis Scientiarum Budapestinensis 32, 149–168.

Galácz, A. 1999b: Middle Jurassic ammonites of Arabian origin in Western Sicily. Neues Jahrbuch für Geologie und Paläontologie Monatshefte 10, 605–613.

Garnier, A. 1872: Réunion extraordinaire à Digne. Bulletin de la Société Geologique de France 29, 626–656.

Géczy, B. & Galácz, A. 1998: Bathonian ammonites from the classic Middle Jurassic locality of Villány, South Hungary. Revue de Paléobiologie 17, 479–511.

Goguel, J. 1966: Carte géologique à l'échelle 1:80000, feuille Castellane. BRGM, Paris.

Graciansky, P.-C. de, Durozoy, G. & Gigot, P. 1982: Carte géologique de la France à 1:50000, Digne. BRGM, Paris, 75 pp.

Graciansky, P.-C. de, Dardeau, G., Dumont, T., Jacquin, T., Marchand, D., Mouterde, R. & Vail, P.R. 1993: Depositional sequence cycles, transgressive-regressive facies cycles, and extensional tectonics, example from the southern subalpine Jurassic basin, France. Bulletin de la Société géologique de France 164, 709–718.
Graciansky, P.-C. de, Dardeau, G., Dommergues, J.L., Dyrlet, C., Marchand, D. Dumont, T.,Hesselbo, S.P.,Jacquin, T.,Goggin, V.,Meister, C.,Mouterde, R., Rey, J. & Vail, P.R. 1998a: Ammonite biostratigraphic correlation and Early Jurassic sequence stratigraphy in France: Comparisons with some U.K. sections. SEPM Special Publication No. 60, 583–622.
Graciansky, P.-C. de, Dardeau, G., Bodeur, Y., Elmi, S., Fortwengler, D., Jacquin, T., Marchand, D. & Thierry, J. 1998b: Les Terres Noires du Sud-Est de la France (Jurassique moyen et supérieur): interprétation en termes de stratigraphie séquentielle. Bulletin du Centre de Recherches Elf Exploration–Production 22, 35–66.
Gradstein, F.M. & Ogg, J.G. 2004: Geologic Time Scale 2004 – why, how and where next! Lethaia 37, 175–181.
Gradstein, F.M., Finney, S.C., Lane, R. & Ogg, J.G. 2003: ICS on stage. Lethaia 36, 371–378.
Gradstein, F.M., Ogg, J.G. & Smith, A.G. (Eds.) 2005: A Geologic Time Scale 2004. Cambridge University Press, Cambridge, 589 pp.
Gräfe, K.-U. 2005: Benthic foraminifers and palaeoenvironment in the Lower and Middle Jurassic of the Western Basque-Cantabrian Basin (Northern Spain). Journal of Iberian Geology 31, 217–233.
Gröschke, M. 1996: Zwei neue Ammoniten der Gattung *Iniskinites* aus dem Bathonium (Mitteljura) von Nordchile. Neues Jahrbuch für Geologie und Paläontologie Monatshefte 1996, 140–146.
Gröschke, M. & Hillebrandt, A. von 1994: The Bathonian in Northern Chile. Geobios 17, 255–264.
Guillaume, L. 1938: Observations sur la limite inférieure des marnes à *Posinonomya alpina* entre Digne et Castellane. Compte Rendu Sommaire des Séances de la Société Géologique de France, 189–199.
Hall, R.L. 1984: Lithostratigraphy and biostratigraphy of the Fernie Formation (Jurassic) in the southern Canadian Rocky Mountains. Canadian Society of Petroleum Geologists Memoir 9, 233–247.
Hall, R.L. 1988: Late Bajocian and Bathonian (Middle Jurassic) ammonites from the Fernie Formation, Canadian Rocky Mountains. Journal of Paleontology 62, 575–586.
Hall. R.L. 1989: New Bathonian (Middle Jurassic) ammonite faunas from the Fernie Formation, southern Alberta. Canadian Journal of Earth Sciences 26, 16–22.
Hall. R.L. & Stronach, N.J. 1981: First record of late Bajocian (Jurassic) ammonites in the Fernie Formation, Alberta. Canadian Journal of Earth Sciences 18, 919–925.
Hall, R. & Westermann, G.E.G. 1980: Lower Bajocian (Jurassic) cephalopod faunas from Western Canada and proposed assemblage zones for the Lower Bajocian of North America. Palaeontographica Americana 9, 1–93.
Hallam, A. 1994: An outline of Phanerozoic Biogeography. Oxford University Press, Oxford, 246 pp.
Halloy J.J. d'O. 1843: Précis élémentaire de géologie. A. Bertrand Ed., Paris, 790 pp.
Hardenbol, J., Thierry, J., Farley, M.B., Jacquin, T., Graciansky, P-C. de & Vail, P.R. 1998: Mesozoic and Cenozoic sequence chronostratigraphic framework of European Basins. In: Graciansky, P.C. de, Hardenbol, J., Jacquin, T. & Vail, P.R. (Eds.): Mesozoic and Cenozoic Sequence Stratigraphy of European Basins. SEPM (Society for Sedimentary Geology) Special Publication 60, Tulsa, Oklahoma, 3–14.
Harland, W.B., Cox, A.V., Llewellyn, P.G., Pickton, C.A.G., Smith, A.G. & Walters, R. 1982: A Geologic Time Scale. Cambridge University Press, Cambridge, 131 pp.
Haug, E. 1891: Les Chaînes Subalpines entre Gap et Digne. Bulletin du Service de la Carte Géologique de France 3, 21, 1–192.
Henriques, M. & Ramalho, M.M. 2005: Jurassic Heritage of Cabo Mondego (Central Portugal). In: Henriques, M.H. (Coord.): Jurassic Heritage and Geoconservation in Portugal: Selected Sites. Field Trip Guide Book. IV International Symposium ProGEO on the Conservation of the Geological Heritage. Geosciences Centre, Coimbra, 37–43.
Hillebrandt, A. von 1995: A Late Bathonian morphoceratid (Jurassic, Ammonitina) from Peru. Mitteilungen der Bayerischen Staatssammlung für Paläontologie und Historische Geologie 35, 27–37.
Hillebrandt, A. von 2001. Ammonite stratigraphy of the Bajocian in Northern Chile. Hantkeniana 3, 49–87.
Hillebrandt, A. von, Smith, P., Westermann, G.E.G. & Callomon, J.H. 1992a: Ammonites zones of the circum-Pacific region. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 247–272.
Hillebrandt, A. von, Westermann, G.E.G., Callomon, J.H., Detterman, R.L. 1992b: Ammonites of the circum-Pacific region. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 342–359
Imlay, R.W. 1980: Middle Jurassic (Bathonian) ammonites from Southern Alaska. U. S. Geological Survey Professional Paper 1091, 1–42.
Imlay, R.W. 1981: Jurassic (Bathonian and Callovian) ammonites in Eastern Oregon and Western Idaho. U. S. Geological Survey Professional Paper 1142, 1–24.
Imlay, R.W. 1982: Late Bajocian ammonites from Southern Alaska. U.S. Geological Survey Professional Paper 1189, 1–21.
Imlay, R.W. 1984: Jurassic ammonite successions in North America and biogeographic implications. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 1–12.
Innocenti, M., Mangold, C., Pavia, G. & Torrens, H.S. 1990: A proposal for the formal ratification of the basal boundary stratotype of the Bathonian Stage based on a Bas Auran section (S.E. France). In: Rocha, R.B. & Soares, A.F. (Eds.): 2nd International Symposium on Jurassic Stratigraphy 1987 (1988). Centro de Estratigrafia e Paleobiologia, Universidade Nova de Lisboa, Lisbon, 333–346.
Jacquin, T., Dardeau, G., Durlet, C., Graciansky, P.C. de & Hantzpergue, P. 1998: The North Sea Cycle: an overview of 2nd-order transgressive/regressive facies cycles in Western Europe. In: Graciansky, P.C. de, Hardenbol, J., Jacquin, T. & Vail, P.R. (Eds.): Mesozoic and Cenozoic Sequence Stratigraphy of European Basins. SEPM (Society for Sedimentary Geology) Special Publication, No. 60, Tulsa, Oklahoma, 445–466.
Jana, B.N. & Hilton, J. 2007: Resolving the age of the Mesozoic Kuar Bet Beds (Kachchh, Gujarat, India): A reinvestigation of palaeobotanical and palynological assemblages. Journal of Asian Earth Sciences 30, 457–463.
Jaitly, A.K. & Singh, C.S.P. 1983: Discovery of the Late Bajocian-Leptosphinctes Buckman (Jurassic Ammonitina) from Kachcch, Western India. Neues Jahrbuch für Geologie und Paläontologie Monatshefte 1983, 91–96.
Jaitly, A.K. & Singh, C.S.P. 1984: On the Bathonian (Middle Jurassic) ammonites *Micromphalites* Buckman and *Gracilisphinctes* Buckman from Kachchh, Western India. Geological Magazine 121, 319–321.
Jenkyns, H., Jones, C., Gröcke, D., Hesselbo, S. & Parkinson, N. 2002: Chemostratigraphy of the Jurassic System: applications, limitations and implications for palaeoceanography. Journal of the Geological Society, London 159, 351–378.
Joly, B. 2000: Les Juraphyllitidae, Phylloceratidae, Neophylloceratidae (Phylloceratаceae, Phylloceratina, Ammonoidea) de France au Jurassique et au Crétacé. Geobios 23, 1–204.
Kaenel, E. de & Bergen, J.A., 1993: New Early and Middle Jurassic coccolith taxa and biostratigraphy from the eastern proto-Atlantic (Morocco, Portugal and DSDP Site 547B). Eclogae geologicae Helvetiae 86, 861–907.
Kaenel, E. de, Bergen, J.A. & Salis Perch-Nielsen, K. von 1996: Jurassic calcareous nannofossil biostratigraphy of Western Europe. Compilation of recent studies and calibration of bioevents. Bulletin de la Société Géologique de France 167, 15–28.
Kimura, T., Lebedev, E.L., Markovich, E.M. & Samylina, V.A. 1992: Macroflora of eastern Asia and other circum-Pacific areas. In: Westermann, E. G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 311–316.
Kopik, J. 2006: Bathonian ammonites of the families Sphaeroceratidae Buckman and Tulitidae Buckman from the Polish Jura Chain (Southern Poland). Polish Geological Institute, Special Papers 21, 1–68.
Köstler, L. & Schairer, G. 1996: *Morphoceras* aus dem "Parkinsonien-Oolith" (Mittlerer Jura) von Segenthal/Opf. Mitteilungen der Bayer-

ischen Staatssammlung für Paläontologie und Historische Geologie 36, 81–85.
Krystyn, L. 1972: Die Oberbajocium- und Bathonium-Ammoniten der Klaus-Schichten des Steinbruches Neumühle bei Wien (Österreich). Annalen des Naturhistorischen Museum in Wien 76, 195–310.
Lemoine, M. 1984: Mesozoic evolution of the western Alps. Annales Geophysicae 2, 171–172.
Lemoine, M. 1985: Structuration jurassique des Alpes occidentales et palinspastiques de la Téthys ligure. Bulletin de la Société Géologique de France 8, 126–137.
Luczynski, P., Matyja, B. A. & Wierzbowski, A. 2000: Ontogeny and ecological interpretation of the ammonites of the Asphinctites-Polysphinctites group (Tenuiplicatus Zone, lower Bathonian). Bajocian-Bathonian Working Groups Meeting, Budapest, 23–24.
Majidifard, M.R. 2003: Biostratigraphy, Lithostratigraphy, ammonite taxonomy and microfacies analysis of the Middle and Upper Jurassic of norteastern Iran. Unpublished PhD Thesis of the Bayerische Julius-Maximilians-Universität Würzburg, 201 pp.
Manceñido, M.O. & Dagys, A.S. 1992: Brachiopods of the circum-Pacific region. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 328–333.
Mangold, C. 1971a: Stratigraphie des étages Bathonien et Callovien du Jura Méridional. Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon 41/1, (1970), 1–376.
Mangold, C. 1971b: Les Perisphinctidae (Ammonitina) du Jura Méridional au Bathonien et au Callovien. Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon 41/2 (1970), 1–246.
Mangold, C. 1971c: Morphoceratidae (Ammonoidea, Perisphinctidae) bathoniens du Jura méridional, de la Nièvre et du Portugal. Geobios 3 (1970), 43–130.
Mangold, C. 1981: Le Bathonien de l'Est du Subbétique (Espagne du Sud). Cuadernos de Geología 10 (1979), 271–281.
Mangold, C. 1984: Report of the Bathonian Working Group. In: Michelsen O.& Zeiss A. (Eds.): 1st International Symposium on Jurassic Stratigraphy (IUGS). Geological Survey of Denmark, Copenhagen, 67–75.
Mangold, C. 1990: Le Bathonien du Cap Mondego (N de Figueira da Foz, Portugal). Biochronologie et corrélations. Cahiers de l'Université Catholique de Lyon 4, 89–105.
Mangold, C. 1997a: Tendances évolutives chez les Morphocératidés (Périsphinctacés, Ammonitina). Cahiers de l'Université Catholique de Lyon 10, 93–101.
Mangold, C. 1997b: Le Jurassique moyen. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 355–361.
Mangold C. 1999. Report of the Bajocian-Bathonian boundary Working Group. International Subcommission on Jurassic Stratigraphy, Newsletter 26, 50–52.
Mangold, C. & Gygi, R.A. 1997. Bathonien ammonites from Canton Aargau, Northern Switzerland: stratigraphy, taxonomy and biogeography. Geobios 30, 497–518.
Mangold, C. & Rioult, M. 1997: Bathonien. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 55–62.
Martire, L. 1989: Analisi biostratigrafica e sedimentologica del rosso ammonitico veronese dell'Altopiano di Asiago. Unpublished PhD Thesis, Torino University, 166 pp.
Martire, L. & Pavia, G. 2004: Jurassic sedimentary and tectonic processes at Montagna Grande (Trapanese Domain, Western Sicily, Italy). Rivista Italiana di Paleontologia e Stratigrafia 110, 23–33.
Mattioli, E. & Erba, E. 1999: Synthesis of calcareous nannofossil events in the Tethyan Lower and Middle Jurassic. Rivista Italiana di Paleontologia e Stratigrafia 105, 343–376.
Matyja, B.A. & Wierzbowski, A. 2000: Ammonites and stratigraphy of the uppermost Bajocian and Lower Bathonian between Czestochowa and Wielun, Central Poland. Acta Geologica Polonica 50, 191–209.
Matyja, B.A. & Wierzbowski, A. 2001: Palaeogeographical distribution of early Bathonian ammonites of the Asphinctites-Polysphinctites group. Hantkeniana 3, 89–103.
Maubeuge, P.L. 1950: Sur le Bathonien et en particulier sur le Bathonien lorrain (note préliminaire). Impr. Thomas, Nancy, 16 pp.
Metz, M. 1990: Ein neues Bajocium-Profil (Mittlerer Jura) im Osnabrücker Bergland (Niedersachsen). Osnabrücker naturwissenschaftliche Mitteilungen 16, 7–30.
Metz, M. 1992: Die Faunenhorizonte der "Subfurcaten-Schichten" (Bajocium, Niortense-Zone) in Nordwestdeutschland. Osnabrücker naturwissenschaftliche Mitteilungen 18, 25–65.
Mitta, V.V. 2001: Distribution of the Bajocian-Bathonian ammonites in the South-West chains of Hissar Range. Hantkeniana 3, 105–129.
Mitta, V.V. 2004: *Sokurella galaczi* gen. et sp. nov. and other Middle Jurassic Parkinsoniidae (Ammonoidea) from the lower reaches of the Volga River. Paleontological Journal 38, 257–264.
Mitta, V.V. 2005: Late Bathonian Cardioceratidae (Ammonoidea) from the Middle Reaches of the Volga River. Paleontological Journal 39, 629–644.
Mitta, V.V. 2006: The First discovery of Arctocephalites (Cardioceratidae, Ammonoidea) from the Middle Jurassic of the Pechora Basin (Northern Russia) [in Russian]. In: Barskov, I. & Leonova, T. (Eds.): Contributions to current cephalopod research, Paleontological Institute, Moscow, 82–84.
Mitta, V.V. 2007: The Boundary of the Bajocian and Bathonian stages in the European Russia [in Russian]. In: Zakharov, V.A. (Ed.): Jurassic System of Russia: problems of Stratigraphy and Paleogeography. Second all-Russian meeting. Yaroslavl State Pedagogical University, Yaroslavl, 161–163.
Mitta, V.V. & Seltzer, V.B. 2002: First finds of Arctocephalitinae (Ammonoidea) in the Jurassic of the south-eastern Russian Platform, and the correlation of the Boreal Bathonian Stage with the standard scale [in Russian]. Transactions of the Scientific Research Geological Institute of the N.G. Chernyshevskii Saratov State University 10, 12–39.
Mitta, V.V., Barskov, I.S., Gründel, J., Zakharov, V.A., Seltzer, V.B., Ivanov, A. V., Rostovtseva, J.A. & Tarasova, L.O. 2004: The Upper Bajocian and Lower Bathonian in the section near Saratov [in Russian]. Vernadsky Museum Novitates 2, 1–39.
Morton, N. 1974: The definition of standard Jurassic Stages. Mémoire du Bureau de Recherches géologiques et minières 75 (1971), 83–93.
Morton, N. 2006: Chronostratigraphic units in the Jurassic and their boundaries: Definition, recognition and correlation, causal mechanisms. Progress in Natural Science 16, 13, 1–11.
Moyne, S. & Neige, P. 2007: The space-time relationship of taxonomic diversity and morphological disparity in the Middle Jurassic ammonite radiation. Palaeogeography, Palaeoclimatology, Palaeoecology 248, 82–95.
Moyne, S., Thierry, J., Marchand, D., Nicolleau, P., Pineau, J.P., Courville, P. & Saucède, T. 2005: Le genre *Nucleolites* (Echinoidea, Cassiduloidea) du Bajocien à l'Oxfordien dans le Bassin de Paris: apport des données architecturales à la systématique et à la phylogénie. Geobios 38, 519–532.
O'Dogherty, L., Sandoval, J., Bartolini, A., Bruchez, S., Bill, M. & Guex, J. 2006: Carbon–isotope stratigraphy and ammonite faunal turnover for the Middle Jurassic in the Southern Iberian palaeomargin. Palaeogeography, Palaeoclimatology, Palaeoecology 239, 311–333.
Ogg, J.G. 2004: Status of Divisions of the International Geologic Time Scale. Lethaia 37, 183–199.
Ohmert, W., Gassmann, G., Kutz, M., Mattes, R. & Müller, R. 2004: Neue Ammonitenfunde aus der Hauptrogenstein-Formation (Mitteljura) des Breisgaus (Oberrhein). Jahresberichte und Mitteilungen des Oberrheinischen Geologischen Vereines 86, 337–350.
Olivero, D. 1994: La trace fossile *Zoophycos* du Jurassique du Sud-Est de la France. Signification paleoenvironnementale. Documents des Laboratoires de Géologie Lyon 129, 1–329.
Olivero, D. 2003: Early Jurassic to Late Cretaceous evolution of *Zoophycos* in the French Subalpine Basin (southeastern France). Palaeogeography, Palaeoclimatology, Palaeoecology 192, 59–78.
Olivero, D. & Atrops, F. 1996: Les séries à *Zoophycos* du Bathonien-Callovien de l'Arc de Castellane (SE de la France) dans la zone de transition plate-forme/basin: stratigraphie et paléotectonique. Comptes Rendus de l'Académie des Sciences de Paris 323, 81–88.
Olivero, D., Mangold, C. & Pavia, G. 1997: La formation des Calcaires à *Zoophycos* du Verdon (Bathonien inférieur à Callovien moyen) des environs de Castellane (Alpes-de-Haute-Provence, France): biochronologie et lacunes. Comptes Rendus de l'Académie des Sciences de Paris 324, 33–40.

Oppel, A. 1856–1858: Die Juraformation Englands, Frankreichs und des südwestlichen Deutschlands, nach ihren einzelnen Gliedern eingeteilt und verglichen. Ebner & Seubert Verlag, Stuttgart, 857 pp.

Oppel, A. 1862: Über jurassische Cephalopoden. Paläontologische Mittheilungen aus dem Museum des Koeniglichen Bayerischen Staates 3, 127–266.

Oppel, A. 1865: Geognostische Studien in den Ardèche Departement. Paläontologische Mittheilungen aus dem Museum des Koeniglichen Bayerischen Staates 5, 305–322.

Orbigny, A. d' 1842–1851: Paléontologie française. Terrain Jurassique. 1. Céphalopodes. Masson Ed., Paris, 641 pp.

Orbigny, A. d' 1849–1852: Cours élémentaire de paléontologie et de géologie stratigraphiques. Masson Ed., Paris, 1145 pp.

Ouahhabi, B. 1994: Le Lias et le Dogger inférieur des Beni Snassen orientaux (Maroc). Stratigraphie, paléontologie et dinamique du bassin. Comparaison avec les Monts d'Oujda et avec les régions limitrophes. Unpublished PhD Thesis, Oujda University, 496 pp.

Page, K.N. 1996a: Mesozoic Ammonoids in space and time. In: Landmann, N.H., Tanabe, K. and R.A. Davis (Eds.): Ammonoid Paleobiology. Topics in Geobiology 13, 755–794.

Page, K.N. 1996b: Observations on the succession of stratigraphically useful ammonite faunas in the Bathonian (Middle Jurassic) of south-west England, and their correlation with a Sub-Mediterranean "Standard Zonation". Proceedings of the Ussher Society 9, 45–53.

Page, K.N. 2001: Up a Bathonian backwater – a review of the ammonite evidence for correlating sequences with interdigitating non-marine facies in central and northern England. Hantkeniana 3, 131–148.

Page, K.N., Meléndez, G. & Henriques, M.H. 2006: Jurassic Global Stratotype Section and Points (GSSPs) – a potential serial World Heritage Site? Volumina Jurassica 7, p. 253.

Pandey, D.K. & Agrawal, S.K. 1984: On two new species of the Middle Jurassic ammonite genus Clydoniceras Blake from Kachchh, western India. Neues Jahrbuch für Geologie und Paläontologie Monatshefte 1984, 321–326.

Pandey, D.K. & Callomon, J.H. 1995: Contributions to the Jurassic of Kachchh, Western India. III. The Middle Bathonian ammonite families Clydoniceratidae and Perisphinctidae from Pachchham Island. Beringeria 16, 125–145.

Pandey, D.K. & Westermann, G.E.G. 1988: First record of Bathonian *Bullatimorphites* (Jurassic, Ammonitina) from Kackchh, India. Journal of Paleontology 62, 148–150.

Parkinson, D.N. 1996: Gamma-ray spectrometry as a tool for stratigraphical interpretation: examples from the western European Lower Jurassic. Geological Society, London, Special Publications 103, 231–255.

Parent, H. 1998: Upper Bathonian and Lower Callovian ammonites from Chacay Melehué (Argentina). Acta Paleontologica Polonica 42, 69–130.

Parnes, A. 1981: Biostratigraphy of the Mahmal Formation (Middle and Upper Bajocian) in Makhtesh Ramon (Negev, Southern Israel). Geological Survey of Israel, Bulletin. 74, 1–55.

Parnes, A. 1984: Irregularly coiled Stephanoceratidae from the Upper Bajocian of Gebel Maghara, Sinai, Egypt. Geological Survey of Israel, Current Research 1983–84, 29–32.

Parnes, A. 1988: Middle Jurassic (Middle Bajocian – Middle Bathonian) ammonites from Gebel Maghara, Sinai, Egypt. In the collections of the Geological Survey of Israel. Journal of African Earth Sciences 7, 707–733.

Patrulius, D. 1996: Ammonites hétéromorphes et autres Parkinsoniidés du Bathonien-Callovien inférieur de Vadu Crisului (Monts Apuseni – Roumanie). Mémoires Institut de Géologie et de Géophysique 36, 13–19.

Pavia, G. 1973: Ammoniti del Baiociano superiore di Digne (Francia SE, Dip. Basses-Alpes). Bollettino della Società Paleontologica Italiana 10, 2 (1971), 75–142.

Pavia, G. 1983a: Il genere *Ptychophylloceras* Spath, 1927 (Ammonoidea, Phylloceratаceae) nel Baiociano sudeuropeo. Atti della Accademia Nazionale dei Lincei, Memorie 1982, 17, 1–31.

Pavia, G. 1983b: New data on *Orthogarantiana* (Torrensia) Sturani, 1971 (Ammonitina, Stephanocerataceae) in the European Upper Bajocian. Bolletino del Museo Regionale di Scienze Naturali de Torino 1, 201–214.

Pavia, G. 1984: Bajocien et Bathonien de l'Arc de Digne. In: Debrand-Passard, S. (Ed.). Synthèse geologique du Sud-Est de la France. Mémoire B.R.G.M. 125, 199–200.

Pavia, G. 1994: Taphonomic remarks on d'Orbigny's type-Bajocian (Bayeux, west France). Servizio Geologico Nazionale, Miscellanea 5, 93–111.

Pavia, G. 2000: New Subcollina (Ammonitida) from the topmost Lower Bajocian: their phylogenetic and palaeogeographic significance. GeoReseach Forum 6, 397–406.

Pavia, G. 2007: Lissoceras monachum (Gemmellaro), a ghost Ammonitida of the Tethyan Bathonian. Bollettino della Società Paleontologica Italiana 45 (2006), 217–226.

Pavia, G. & Cresta, S. (Coords.) 2002: Revision of Jurassic ammonites of the Gemmellaro collections. Quaderni del Museo Geologico "G.G. Gemmellaro" 6, 1–408.

Pavia, G. & Sturani, C. 1968: Étude biostratigraphique du Bajocien des Chaînes Subalpines aus environs de Digne (Basses-Alpes). Bollettino della Società Geologica Italiana 87, 305–316.

Pavia, G., Martire, L., Canzoneri, V. & D'Arpa, C. 2002: Rocca chi Parra quarry, a condensed Rosso Ammonitico succession: depositional and erosional geometries, neptunian dykes and ammonite assemblages. In: Santantonio, M. (Ed.): General Field Trip Guidebook. VI International Symposium on the Jurassic System, Palermo, 42–48.

Pavia, G., Fernández-López, S.R. & Mangold, C. 2008: Ammonoid succession at the Bajocian-Bathonian transition in the Bas Auran area, Digne district, South-East France. Rivista Italiana di Paleontologia e Stratigrafia, in litt.

Pawellek, T. & Aigner, T. 2003: Stratigraphic architecture and gamma ray logs of deeper ramp carbonates (Upper Jurassic, SW Germany). Sedimentary Geology 159, 203–240.

Pawellek, T. & Aigner, T. 2004: Dynamic stratigraphy as a tool in economic mineral exploration: ultra-pure limestones (Upper Jurassic, SW Germany). Marine and Petroleum Geology 21, 499–516.

Pellenard, P., Deconinck, J.-F., Huff, W.D., Thierry, J., Marchand, D., Fortwengler, D. & Trouiller, A. 2003: Characterization and correlation of Upper Jurassic (Oxfordian) bentonite deposits in the Paris Basin and the Subalpine Basin, France. Sedimentology 50, 1035–1060.

Pessagno, E. Jr. & Mizutani, S. 1992: Radiolarian biozones of North America and Japan. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 293–295.

Poulsen, N.E. 1997: Report on samples from Bas Auran, SE France. Jurassic Microfossil Group Newsletter 6, 9–10.

Poulsen, N.E. & Riding, J.B. 2003: The Jurassic dinoflagellate cyst zonation of Subboreal Northwest Europe. Geological Survey of Denmark and Greenland Bulletin 1, 115–144.

Poulton, T.P. 1987: Zonation and correlation of Middle Boreal Bathonian to lower Callovian (Jurassic) ammonites, Salmon Cache Canyon, Porcupine River, northern Yukon. Geological Survey of Canada, Bulletin 358, 1–155.

Poulton, T.P., Hall, R.L., Tipper, H.W., Cameron, B.E.B. & Carter, E.S. 1991: Current status of Middle Jurassic biostratigraphy of the Queen Charlotte Islands, British Columbia. Geological Survey of Canada, Paper 90–10, 237–252.

Poulton, T.P., Hall, R.L. & Callomon, J.H. 1994: Ammonite and bivalve assemblages in Bathonian through Oxfordian strata of northern Bowser Basin, northwestern British Columbia, Canada. Geobios M.S. 17, 415–421.

Prasad, S., Jain, R.L. & Srivastava, M.S. 2007: Record of Middle Jurassic (Bathonian) ammonite genus Clydoniceras Blake from Jaisalmer Basin, western Rajasthan. Journal of the Geological Society of India 69, 53–56.

Raddadi, M.C., Vanneau, A.A., Poupeau, G., Carrio-Schaffhauser, E., Arnaud, H. & Rivera, A. 2005: Interpretation of gamma-ray logs: The distribution of uranium in carbonate platform. Comptes Rendus Geosciences 337, 1457–1461.

Rawson, P.F. 1982: New Arctocephalitinae (Ammonoidea) from the Middle Jurassic of Kong Karls Land, Svalbard. Geological Magazine 119, 95–100.

Remane, J., Bassett, M.G., Cowie, J.W., Gorhbrandt, K.H., Lane, H.R., Milchelson, O. & Wang, N. 1996: Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission of Stratigraphy (ICS). Episodes 19, 77–81.

Riccardi, A.C. 1985: Los Eurycephalitinae andinos (Ammonitina, Jurásico Medio): modelos evolutivos y resolución paleontológica. Boletín Gent. Inst. Fitolec. Castelar 13, 1–27.

Riccardi, A.C. 1991: Jurassic and Cretaceous marine connections between the Southeast Pacific and Tethys. Palaeogeography, Palaeoclimatology, Palaeoecology 87, 155–189.

Riccardi, A.C. & Westermann, G.E.G. 1991a: Middle Jurassic ammonite fauna and biochronology of the Argentine-Chilean Andes. Part III: Bathonian-Callovian Eurycephalitinae, Stephanocerataceae. Palaeontographica 216, 1–110.

Riccardi, A.C. & Westermann, G.E.G. 1991b: Middle Jurassic ammonite fauna and biochronology of the Argentine-Chilean Andes. Part IV: Bathonian-Callovian Reineckeiidae. Palaeontographica 216, 111–145.

Riccardi, A.C. & Westermann, G.E.G. 1999: An early Bathonian Tethyan ammonite fauna from Argentina. Palaeontology 42, 193–209.

Riccardi, A.C., Westermann, G.E.G. & Elmi, S. 1990a: The Middle Jurassic Bathonian-Callovian Ammonite Zones of the Argentine-Chilean Andes. Geobios 22 (1989), 553–597.

Riccardi, A.C., Westermann, G.E.G. & Damborenea, S.E. 1990b: Middle Jurassic of South America and Antarctic Peninsula. Newsletter on Stratigraphy 21, 105–128.

Riccardi, A.C., Westermann, G.E.G. & Elmi, S. 1991: Biostratigraphy of the upper Bajocian-middle Callovian (Middle Jurassic), South America. Journal of South American Earth Sciences 4, 149–157.

Riccardi, A.C., Gulisano, C.A., Mojica, J., Palacios, O., Schubert, C. & Thomson, M.R.A. 1992: Western South America and Antartica. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 122–161.

Riccardi, A.C., Damborenea, S.E., Manceñido, M.O. & Ballent, S.C. 1994: Middle Jurassic biostratigraphy of Argentina. Geobios 17, 423–430.

Riding, J.B. & Thomas, J.E. 1992: Dinoflagellate cysts of the Jurassic System. In: Powell A.J. (Ed.): A stratigraphic index of dinoflagellate cysts. Chapman & Hall, London, 7–97.

Rioult, M. 1964: Le stratotype du Bajocien. Colloque du Jurassique Luxembourg 1962, Comptes Rendus et Mémoires. Institut Grand-Ducal, Luxembourg, 239–258.

Rioult, M., Contini, D., Elmi, S. & Gabilly, J. 1997: Bajocien. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 41–53.

Rocha, R., Manuppella, G., Mouterde, R., Ruget, C. & Zbyszewski, G. 1981: Carta geológica de Portugal, 1/50000, folha 19-C, Figueira da Foz. Serviços Geológicos de Portugal, Lisbon.

Rocha, R.B., Mouterde, R., Soares, A.F. & Elmi, S. 1987: Excursion A – Biostratigraphie et évolution séquentielle du Bassin au Nord du Tage au cours du Lias et du Dogger. International Subcommission on Jurassic Stratigraphy, Centro de Estratigrafia e Paleobiologia da UNL (INIC), Lisbon, 84 pp.

Rostovtsev, K.O. 1985. The Jurassic deposits of the south part of the Transcaucasus [in Russian]. Nauka, Leningrad, 188 pp.

Roy, P., Bardhan, S., Mitra, A. & Jana, S.K. 2007: New Bathonian (Middle Jurassic) ammonite assemblages from Kutch, India. Journal of Asian Earth Sciences 30, 629–651.

Ruban, D.A. 2006: Taxonomic diversity dynamics of the Jurassic bivalves in the Caucasus: Regional trends and recognition of global patterns. Palaeogeography, Palaeoclimatology, Palaeoecology 239, 63–74.

Ruf, M., Link, E., Pross, J. & Aigner, T. 2005: Integrated sequence stratigraphy: Facies, stable isotope and palynofacies analysis in a deeper epicontinental carbonate ramp (Late Jurassic, SW Germany). Sedimentary Geology 175, 391–414.

Ruget-Perrot, C. 1961: Études stratigraphiques sur le Dogger et le Malm inférieur du Portugal au Nord du Tage. Serviços Geológicos de Portugal, Memória 7, 1–197.

Ruget, C. & Nicollin, J.P. 1997: Les petits foraminifères benthoniques dégagés. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 281–291.

Rulleau, L. 2006: Biostratigraphie et paléontologie du Lias supérieur et du Dogger de la région lyonnaise. Lafarge Ciments, Lozanne, 382 pp.

Saltykov, V.F. 2007: The sequence of the ammonite and foraminifer zones in Bajocian – Bathonian section of the Lower Volga area [in Russian]. In: Zakharov, V.A. (Ed.): Jurassic System of Russia: problems of Stratigraphy and Paleogeography. Second all-Russian meeting. Yaroslavl State Pedagogical University, Yaroslavl, 201–203.

Sandoval, J. 1983: Bioestratigrafía y paleontología (Stephanocerataceae y Perisphinctaceae) del Bajocense y Bathonense en las Cordilleras Béticas. Unpublished PhD Thesis, Granada University, Granada, 613 pp.

Sandoval, J. 1986: Middle Jurassic Haploceratidae (Ammonitina) from the Subbetic Zone (South Spain). Geobios 19, 435–463.

Sandoval, J. 1990: A revision of the Bajocian divisions in the Subbetic Domain (southern Spain). Memoire descrittive della Carta Geologica d'Italia 40, 141–162.

Sandoval, J. 1994: The Bajocian Stage in the Island of Majorca: biostratigraphy and ammonite assemblages. Servizio Geologico Nazionale, Miscellanea 5, 293–215.

Sandoval, J. & Westermann, G.E.G. 1986: The Bajocian ammonite fauna of Oaxaca. Journal of Paleontology 60, 1220–1271.

Sandoval, J., Westermann, G.E.G. & Marshall, M.C. 1990: Ammonite fauna, stratigraphy and ecology of the Bathonian-Callovian (Jurassic) Tecocoyunca Group, South Mexico. Palaeontographica 210, 93–149.

Sandoval, J., O'Dogherty, L. & Guex, J. 2001: Evolutionary rates of Jurassic ammonites in relation to sea-level fluctuations. Palaios 16, 311–335.

Sarjeant, W.A.S., Volkheimer, W. & Zhang, W.P. 1992: Jurassic Palynomorphs of the circum-Pacific region. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 273–292.

Sato, T. 1992: Southeast Asia and Japan. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 194–213.

Schairer, G. 1987: Ammoniten aus Bajoc und Bathon (mittlerer Jura) von Segenthal. Mitteilungen der Bayerischen Staatssammlung für Paläontologie und Historische Geologie 27, 31–50.

Schairer, G. 1994: *Polysphinctites polysphinctus* BUCKMAN aus dem "Parkinsonien-Oolith" von Segenthal. Mitteilungen der Bayerischen Staatssammlung für Paläontologie und Historische Geologie 34, 159–162.

Schlögl, J. & Rakús, M. 2004: Ammonites of Arabian origin from the Early Bathonian of the Czorsztyn Unit, Pieniny Klippen Belt (Western Carpatians, Slovakia). Neues Jahrbuch für Geologie und Paläontologie Monatshefte 2004, 449–460.

Schlögl, J., Rakús, M., Mangold, C. & Elmi, S. 2005: Bajocian – Bathonian ammonite fauna of the Czorsztyn Unit, Pieniny Klippen Belt (Western Carpathians, Slovakia); its biostratigraphical and palaeobiogeographical significance. Acta Geologica Polonica 55, 339–359.

Schlögl, J., Elmi, S., Rakús, M., Mangold, C. & Ouahhabi, M. 2006: Specialization and iterative evolution of some Western Tethyan Bathonian ammonites [Benatinites (B.) nov., B. (Lugariceras) nov. and Hemigarantia]. Geobios 39, 113–124.

Schnyder, J., Ruffell, A., Deconinck, J.F. & Baudin, F. 2006: Conjunctive use of spectral gamma-ray logs and clay mineralogy in defining late Jurassic–early Cretaceous palaeoclimate change (Dorset, U.K.). Palaeogeography, Palaeoclimatology, Palaeoecology 229, 303–320.

Schweigert, G. & Dietze, V. 1998: Revision der dimorphen Ammonitengattungen *Phlycticeras* HYATT – *Oecoptychius* NEUMAYR (Strigoceratidae, Mitteljura). Stuttgarter Beiträge zur Naturkunde 269, 1–59.

Schweigert, G., Dietze, V. & Dietl, G. 2002: Erstnachweis der Ammoniten-Gattung *Parkinsonia* BAYLE, 1878 in der Garantiana-Zone (Tetragona-Subzone). Stuttgarter Beiträge zur Naturkunde 320, 1–15.

Schweigert, G., Dietl, G. & Dietze, V. 2003: Neue Nachweise von *Phlycticeras* und *Oecoptychius* (Ammonitina: Strigoceratidae: Phlycticeratinae). Stuttgarter Beiträge zur Naturkunde 335, 1–21.

Schweigert, G., Dietze, V., Chandler, R.B. & Mitta, V. 2007: Revision of the Middle Jurassic dimorphic ammonite genera *Strigoceras*/*Cadomoceras* (Strigoceratidae) and related forms. Stuttgarter Beiträge zur Naturkunde 373, 1–74.

Seyed-Emami, K., Schairer, G. & Bolourchi, M.H. 1985: Ammoniten aus der unteren Dalichy-Formation (oberes Bajocium bis unteres Bathonium) der Umgebung von Abe-Garm (Avaj, NW-Zentraliran). Zitteliana 12, 57–85.

Seyed-Emami, K., Schairer, G. & Alavi-Naini, M. 1989: Ammoniten aus der unteren Dalichai-Formation (Unterbathon) östlich von Semnan (SE-Alborz, Iran). Müncher geowissenschaftliche Abhandlungen 15, 79–91.

Seyed-Emami, K., Schairer, G., Aghanabati, S.A. & Fazl, M. 1991: Ammoniten aus dem Bathon der Gegend von Tabas – Nayband (Zentraliran). Müncher Geowissenschaftliche Abhandlungen A 19, 65–100.

Seyed-Emami, K., Schairer, G., Aghanabati, S.A., Fürsich, F.T., Senowbari-Daryan, B. & Majidifard, M.R. 1998a: *Cadomites* aus der unteren Bagham-shah-Formation (Oberbathon, Mittlerer Jura) SW Tabas (Zentraliran). Mitteilungen der Bayerischen Staatssammlung für Paläontologie und Historische Geologie 38, 111–119.

Seyed-Emami, K., Schairer, G., Aghanabati, S.A., Fürsich, F.T., Senowbari-Daryan, B. & Majidifard, M.R. 1998b: *Bullatimorphites* aus dem Oberbathon (Mittlerer Jura) SW Tabas (Zentraliran). Mitteilungen der Bayerischen Staatssammlung für Paläontologie und Historische Geologie 38, 121–134.

Singh, C.S.P., Jaitly, A.K. & Pandey, D.K. 1982: First report of some Bajocian-Bathonian (Middle Jurassic) ammonoids and the age of the oldest sediments from Kachchh, W. India. Newsletters on Stratigraphy 11, 37–40.

Singh, C.S.P., Pandey, D.K. & Jaitly, A.K. 1983: Discovery of *Clydoniceras* Blake and *Gracilisphinctes* Buckman (Bathonian-Middle Jurassic Ammonites) in Kachchh, Western India. Journal of Paleontology 57, 821–824.

Soares, A.F., Rocha, R.B., Elmi, S., Henriques, M.H.P., Mouterde, R., Alméras, Y., Ruget, C., Marques, J.F., Duarte, L.V., Carapito, M.C. & Kullberg, J.C. 1993: Le sous-bassin nord lusitanien: histoire d'un rift avorté (Trias-Jurassique moyen, Portugal). Comptes Rendus de l'Académie des Sciences de Paris 317, 1659–1666.

Soussi, M., Mangold, C., Enay, R., Boughdiri, M. & Ben Ismail, M.H. 2000: Le Jurassique inférieur et moyen de la Tunisie septentrionale; corrélations avec l'axe Nord-Sud et paléogéographie. Geobios 33, 437–446.

Steiner, M., Ogg, J. & Sandoval, J. 1987: Jurassic magnetostratigraphy. 3. Bathonian-Bajocian of Carcabuey, Sierra Harana and Campillo de Arenas (Subbetic Cordillera, Southern Spain). Earth and Planetary Science Letters 82, 357–372.

Stephanov, J. 1972: Monograph on the Bathonian ammonite genus *Siemiradzkia* Hyatt, 1900 (nomenclature, taxonomy and phylogeny). Travaux sur la Geologie de Bulgarie 21, 5–82.

Sturani, C. 1967: Ammonites and stratigraphy of the Bathonian in the Digne-Barrême area (South Eastern France). Bolletino della Società Paleontologica Italiana 5, 3–57.

Sturani, C. 1971: Ammonites and stratigraphy of the "Posidonia alpine" beds of the Venetian Alps (Middle Jurassic, mainly Bajocian). Memorie degli Istituti di Geologia e Mineralogia dell' Universita di Padova 28, 1–190.

Sukamto, R. & Westermann, G.E.G. 1992: Indonesia and Papua New Guinea. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 181–193.

Taylor, D.G., Callomon, J.H., Hall, R., Smith, P.L., Tipper, H.W. & Westermann, G.E.G. 1992: Ammonites of the circum-Pacific region. In: Westermann, E.G.E. (Ed.): The Jurassic of the Circum-Pacific. Cambridge University Press, Cambridge, 342–359.

Thierry, J. 2003: Les ammonites du Bathonien-Callovien du Boulonnais: biodiversité, biostratigraphie et biogéographie. Geobios 36, 93–126.

Thierry, J., Clavel, B., Hantzpergue, P., Neraudeau, D., Rigollet, L. & Vadet, A. 1997: Distribution chronologique et géographique des échinides jurassiques en France: essai d'utilisation biostratigraphique. Bulletin du Centre de Recherches Elf Exploration Production, Mémoires 17, 253–271.

Tiraboschi, D. & Erba, E. (in prep.): Calcareous nannofossil biostratigraphy of the Ravin du Bès section (Upper Bajocian-Lower Bathonian, SE France): evolutionary trends of *Watznaueria banesiae* and new morphotypes of the genus *Rucinolithus*.

Torrens, H. 1965: Revised zonal scheme for the Bathonian Stage of Europe. Carpatho-Balkan Geological Association, VII Congress, Reports II, 1, 47–55.

Torrens, H. 1974a: Bathonian Stage. In: N. Morton (Ed.): The definition of standard Jurassic stages. Memoires du Bureau des Recherches Geologiques-Minieres (Paris) 75 (1971), 83–93.

Torrens, H. 1974b: Standard zones of the Bathonian. Memoires du Bureau des Recherches Geologiques-Minieres (Paris) 75 (1971), 581–604.

Torrens, H. 1980: Bathonian correlation chart. In: Cope, J.C.W., Duff, K.L., Parsons, C.F., Torrens, H.S., Wimbledon, W.A. & Wright, J.K. (Eds.): A correlation of Jurassic rocks in the British Isles. Part 2: Middle and Upper Jurassic. Geological Society, Special Report 15, 21–45.

Torrens, H. 1987: Ammonites and stratigraphy of the Bathonian rocks in the Digne-Barrême area (South-Eastern France, Dept. Alpes de Haute Provence). Bolletino della Società Paleontologica Italiana 26, 93–108.

Torrens, H. 2002: From d'Orbigny to the Devonian: some thoughts on the history of the stratotype concept. Comptes rendues Palevol 1, 335–345.

Tseretely, L. 1989: The representatives of family Oppeliidae Bonarelli in Bathonian deposits of Transcaucasus. Metsniereba, Tbilisi, 112 pp.

Vaez-Javadi, F. & Mirzaei-Ataabadi, M. 2006: Jurassic plant macrofossils from the Hojedk Formation, Kerman area, east-central Iran. Alcheringa 30, 63–96.

Vörös A. 2001: Bajocian and Bathonian brachiopods in Hungary: a review. Hantkeniana 3, 177–182.

Wang, Y., Mosbrugger, V. & Zhang, H. 2005: Early to Middle Jurassic vegetation and climatic events in the Qaidam Basin, Northwest China. Palaeogeography, Palaeoclimatology, Palaeoecology 224, 200–216.

Watkinson, M. P. 1989: Triassic to Middle Jurassic sequences from the Lusitanian Basin Portugal, and their equivalents in other North Atlantic margin basins. Unpublished PhD Thesis, The Open University, Milton Keynes, 390 pp.

Wendt, J. 1963: Stratigraphisch-paläontologische Untersuchungen im Dogger Westsiziliens. Bolletino della Società Paleontologica Italiana 2, 57–145.

Wendt, J. 1971: Geologia del Monte Erice (provincial di Trapani, Sicilia occidentale). Geologica Romana 10, 53–76.

Wernli, R. & Görög, A. 2007: Protoglobigérines et Oberhauserellidae (Foraminifères) du Bajocien-Bathonien du Jura méridional, France. Revue de micropaléontologie 50, 185–205.

Westermann, G. 1958: Ammoniten-Fauna und Stratigraphie des Bathonien NW-Deutschlands. Beihefte zum Geologischen Jahrbuch 32, 1–103.

Westermann, G.E.G. 1993a: Global bio-events in mid-Jurassic ammonites controlled by seaways. Syxtematics Association Special Volume 47, 187–226.

Westermann, G.E.G. 1993b: New Mid-Jurassic Ammonitina from New Zealand: implications for biogeography and oceanography. GeoResearch Forum 1, 179–185.

Westermann, G.E.G. 1995. Mid-Jurassic Ammonitinia from the Central Ranges of Irian Jaya and the origin of stephanoceratids. Hantkeniana 1, 105–118.

Westermann, G.E.G. 2000: Marine faunal realms of the Mesozoic: review and revision under the new guidelines for biogeographic classification and nomenclature. Palaeogeography, Palaeoclimatology, Palaeoecology 163, 49–68.

Westermann, G.E.G. & Callomon, J.H. 1988: The Macrocephalitinae and associated Bathonian and Early Callovian (Jurassic) ammonoids of the Sula Islands and New Guinea. Palaeontographica 203, 1–90.

Westermann, G.E.G. & Getty, T.A. 1970: New Middle Jurassic Ammonitina from New Guinea. Bulletins of American Paleontology 57, 231–321.

Westermann, G.E.G. & Hudson, N. 1991: The first find of Eurycephalitinae (Jurassic Ammonitina) from New Zealand and biogeographic implications. Journal of Paleontology 65, 689–693.

Westermann, G.E.G. & Riccardi, A.C. 1980: The Upper Bajocian ammonite *Strenoceras* in Chile: first circum-Pacific record of the Subfurcatum Zone. Newsletters on Stratigraphy 9, 19–29.

Westermann, G.E.G., Riccardi, A.C., Palacios, O. & Rangel, C. 1980: Jurásico medio en el Perú. Instituto Geológico Minero y Metalúrgico, Boletín 9, 1–47.

Westermann, G.E.G., Hudson, N. & Grant-Mackie, J.A. 2000: Bajocian (Middle Jurassic) Ammonitina of New Zealand. New Zealand Journal of Geology & Geophysics 43, 33–57.

Westermann, G.E.G., Hudson, N. & Grant-Mackie, J.A. 2002: New Jurassic Ammonitina from New Zealand: Bathonian–Callovian Eurycephalitinae. New Zealand Journal of Geology & Geophysics 45, 499–525.

Wierzbowski, A., Jaworska, M. & Krobicki, M. 1999: Jurassic (Upper Bajocian-lowest Oxfordian) ammonitico rosso facies in the Pieniny Klippen Belt, Carpathians, Poland: its fauna, age, microfacies and sedimentary environment. Studia Geologica Polonica 115, 7–74.

Yin, J. 2005: Middle Jurassic (Bathonian–Callovian) ammonites from the Amdo Area, Northern Tibet. Acta Palaeontologica Sinica 44, 1–16.

Yin, J., Callomon, J.H. & Enay, R. 2000: A hiatus of 8 My duration in the Middle Jurassic with ammonite succession in Tethyan Himalaya (South Tibet. Geobios 33, 201–210.

Zakharov, V.A. 2007: State of stage and zonal scales of the Jurassic System: global and regional aspects. In: Zakharov, V.A. (Ed.): Jurassic System of Russia: problems of Stratigraphy and Paleogeography. Second all-Russian meeting. Yaroslavl State Pedagogical University, Yaroslavl, 68–74.

Zakharov, V.A., Bogomolov, Yu.I., Il'ina, V.I., Konstantinov, A.G., Kurushin, N.I., Lebedeva, N.K., Meledina, S.V., Nikitenko, B.L., Sobolev, E.S. & Shurygin B.N. 1998: Boreal zonal standard and biostratigraphy of the Siberian Mesozoic. Russian Geology and Geophysics 38 (1997), 965–993.

Zany, D., Atrops, F., Marchand, D. & Thierry, J. 1990: Nouvelles données biostratigraphiques sur les series du Bathonien et du Callovien des environs de Digne (Alpes-de-Haute-Provence). Géologie Méditerranéenne 17, 39–53.

Zaton, M. 2006: *Tulites cadus* Buckman, 1921 (Ammonoidea) from the Middle Bathonian of the Po1ish Jura and its biostratigraphic significance. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen 243, 191–199.

Zaton, M. & Marynowski, L. 2006: Ammonite fauna from uppermost Bajocian (Middle Jurassic) calcitic concretions from the Polish Jura – biogeographical and taphonomical implications. Geobios 39, 426–442.

Ziegler, P.A. 1988: Evolution of the Arctic-North Atlantic and the Western Tethys. American Association Petroleum Geologists Memoir 43, 198 pp.

Zürcher, P. 1895: Compte rendu de la course du 23 septembre de Digne à Barrême. Bulletin de la Société Géologique de France 23, 866–873.

Manuscript received March 21, 2008
Manuscript accepted March 3, 2009
Published Online first June 8, 2009
Editorial Handling: D. Marty & J.-P. Billon-Bruyat